



OcNOS®

Open Compute Network Operating System for Service Providers Version 6.5.4

Multi-Protocol Label Switching Guide

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Preface

This guide describes how to configure MPLS for OcNOS.

IP Maestro Support

Monitor devices running OcNOS Release 6.3.4-70 and above using IP Maestro software.

Audience

This guide is intended for network administrators and other engineering professionals who configure MPLS for OcNOS.

Conventions

[Table P-1](#) shows the conventions used in this guide.

Table P-1: Conventions

Convention	Description
<i>Italics</i>	Emphasized terms; titles of books
Note:	Special instructions, suggestions, or warnings
<code>monospaced type</code>	Code elements such as commands, parameters, files, and directories

Chapter Organization

The chapters in command references are organized as described in [Command Description Format](#).

The chapters in configuration guides are organized into these major sections:

- An overview that explains a configuration in words
- Topology with a diagram that shows the devices and connections used in the configuration
- Configuration steps in a table for each device where the left-hand side shows the commands you enter and the right-hand side explains the actions that the commands perform
- Validation which shows commands and their output that verify the configuration

Related Documentation

For information about installing OcNOS, see the *Installation Guide* for your platform.

Migration Guide

Check the *Migration Guide* for configuration changes to make when migrating from one version of OcNOS to another.

Feature Availability

The features described in this document are available depending upon the OcNOS SKU that you purchased. See the *Feature Matrix* for a description of the OcNOS SKUs.

Support

For support-related questions, contact support@ipinfusion.com.

Comments

If you have comments, or need to report a problem with the content, contact techpubs@ipinfusion.com.

Command Line Interface

This chapter introduces the OcNOS Command Line Interface (CLI) and how to use its features.

Overview

You use the CLI to configure, monitor, and maintain OcNOS devices. The CLI is text-based and each command is usually associated with a specific task.

You can give the commands described in this manual locally from the console of a device running OcNOS or remotely from a terminal emulator such as `putty` or `xterm`. You can also use the commands in scripts to automate configuration tasks.

Command Line Interface Help

You access the CLI help by entering a full or partial command string and a question mark “?”. The CLI displays the command keywords or parameters along with a short description. For example, at the CLI command prompt, type:

```
> show ?
```

The CLI displays this keyword list with short descriptions for each keyword:

```
show ?
  application-priority      Application Priority
  arp                      Internet Protocol (IP)
  bfd                      Bidirectional Forwarding Detection (BFD)
  bgp                      Border Gateway Protocol (BGP)
  bi-lsp                   Bi-directional lsp status and configuration
  bridge                   Bridge group commands
  ce-vlan                  COS Preservation for Customer Edge VLAN
  class-map                Class map entry
  cli                      Show CLI tree of current mode
  clns                     Connectionless-Mode Network Service (CLNS)
  control-adjacency        Control Adjacency status and configuration
  control-channel          Control Channel status and configuration
  cspf                     CSPF Information
  customer                 Display Customer spanning-tree
  cvlan                    Display CVLAN information
  debugging                Debugging functions (see also 'undebug')
  etherchannel             LACP etherchannel
  ethernet                 Layer-2
  ...
```

If you type the ? in the middle of a keyword, the CLI displays help for that keyword only.

```
> show de?
debugging  Debugging functions (see also 'undebug')
```

If you type the ? in the middle of a keyword, but the incomplete keyword matches several other keywords, OcNOS displays help for all matching keywords.

```
> show i? (CLI does not display the question mark).
interface  Interface status and configuration
ip         IP information
isis       ISIS information
```

Command Completion

The CLI can complete the spelling of a command or a parameter. Begin typing the command or parameter and then press the tab key. For example, at the CLI command prompt type `sh`:

```
> sh
```

Press the tab key. The CLI displays:

```
> show
```

If the spelling of a command or parameter is ambiguous, the CLI displays the choices that match the abbreviation. Type `show i` and press the tab key. The CLI displays:

```
> show i
interface ip          ipv6      isis
> show i
```

The CLI displays the `interface` and `ip` keywords. Type `n` to select `interface` and press the tab key. The CLI displays:

```
> show in
> show interface
```

Type `?` and the CLI displays the list of parameters for the `show interface` command.

```
> show interface
IFNAME  Interface name
|       Output modifiers
>       Output redirection
<cr>
```

The CLI displays the only parameter associated with this command, the `IFNAME` parameter.

Command Abbreviations

The CLI accepts abbreviations that uniquely identify a keyword in commands. For example:

```
> sh int xe0
```

is an abbreviation for:

```
> show interface xe0
```

Command Line Errors

Any unknown spelling causes the CLI to display the error `Unrecognized command` in response to the `?`. The CLI displays the command again as last entered.

```
> show dd?
% Unrecognized command
> show dd
```

When you press the Enter key after typing an invalid command, the CLI displays:

```
(config)#router ospf here ^
% Invalid input detected at '^' marker.
```

where the `^` points to the first character in error in the command.

If a command is incomplete, the CLI displays the following message:

```
> show
% Incomplete command.
```

Some commands are too long for the display line and can wrap mid-parameter or mid-keyword, as shown below. This does *not* cause an error and the command performs as expected:

```
area 10.10.0.18 virtual-link 10.10.0.19 authent
ication-key 57393
```

Command Negation

Many commands have a `no` form that resets a feature to its default value or disables the feature. For example:

- The `ip address` command assigns an IPv4 address to an interface
- The `no ip address` command removes an IPv4 address from an interface

Syntax Conventions

[Table P-2](#) describes the conventions used to represent command syntax in this reference.

Table P-2: Syntax conventions

Convention	Description	Example
monospaced font	Command strings entered on a command line	<code>show ip ospf</code>
lowercase	Keywords that you enter exactly as shown in the command syntax.	<code>show ip ospf</code>
UPPERCASE	See Variable Placeholders	<code>IFNAME</code>
()	Optional parameters, from which you must select one. Vertical bars delimit the selections. Do not enter the parentheses or vertical bars as part of the command.	<code>(A.B.C.D <0-4294967295>)</code>
()	Optional parameters, from which you select one or none. Vertical bars delimit the selections. Do not enter the parentheses or vertical bars as part of the command.	<code>(A.B.C.D <0-4294967295>)</code>
()	Optional parameter which you can specify or omit. Do not enter the parentheses or vertical bar as part of the command.	<code>(IFNAME)</code>
{ }	Optional parameters, from which you must select one or more. Vertical bars delimit the selections. Do not enter the braces or vertical bars as part of the command.	<code>{intra-area <1-255> inter-area <1-255> external <1-255>}</code>

Table P-2: Syntax conventions (Continued)

Convention	Description	Example
[]	Optional parameters, from which you select zero or more. Vertical bars delimit the selections. Do not enter the brackets or vertical bars as part of the command.	[<1-65535> AA:NN internet local-AS no-advertise no-export]
?	Nonrepeatable parameter. The parameter that follows a question mark can only appear once in a command string. Do not enter the question mark as part of the command.	?route-map WORD
.	Repeatable parameter. The parameter that follows a period can be repeated more than once. Do not enter the period as part of the command.	set as-path prepend .<1-65535>

Variable Placeholders

Table P-3 shows the tokens used in command syntax use to represent variables for which you supply a value.

Table P-3: Variable placeholders

Token	Description
WORD	A contiguous text string (excluding spaces)
LINE	A text string, including spaces; no other parameters can follow this parameter
IFNAME	Interface name whose format varies depending on the platform; examples are: eth0, Ethernet0, ethernet0, xe0
A.B.C.D	IPv4 address
A.B.C.D/M	IPv4 address and mask/prefix
X:X::X:X	IPv6 address
X:X::X:X/M	IPv6 address and mask/prefix
HH:MM:SS	Time format
AA:NN	BGP community value
XX:XX:XX:XX:XX:XX	MAC address
<1-5> <1-65535> <0-2147483647> <0-4294967295>	Numeric range

Command Description Format

Table P-4 explains the sections used to describe each command in this reference.

Table P-4: Command descriptions

Section	Description
Command Name	The name of the command, followed by what the command does and when should it be used
Command Syntax	The syntax of the command
Parameters	Parameters and options for the command
Default	The state before the command is executed
Command Mode	The mode in which the command runs; see Command Modes
Example	An example of the command being executed

Keyboard Operations

Table P-5 lists the operations you can perform from the keyboard.

Table P-5: Keyboard operations

Key combination	Operation
Left arrow or Ctrl+b	Moves one character to the left. When a command extends beyond a single line, you can press left arrow or Ctrl+b repeatedly to scroll toward the beginning of the line, or you can press Ctrl+a to go directly to the beginning of the line.
Right arrow or Ctrl+f	Moves one character to the right. When a command extends beyond a single line, you can press right arrow or Ctrl+f repeatedly to scroll toward the end of the line, or you can press Ctrl+e to go directly to the end of the line.
Esc, b	Moves back one word
Esc, f	Moves forward one word
Ctrl+e	Moves to end of the line
Ctrl+a	Moves to the beginning of the line
Ctrl+u	Deletes the line
Ctrl+w	Deletes from the cursor to the previous whitespace
Alt+d	Deletes the current word
Ctrl+k	Deletes from the cursor to the end of line
Ctrl+y	Pastes text previously deleted with Ctrl+k, Alt+d, Ctrl+w, or Ctrl+u at the cursor

Table P-5: Keyboard operations (Continued)

Key combination	Operation
Ctrl+t	Transposes the current character with the previous character
Ctrl+c	Ignores the current line and redisplay the command prompt
Ctrl+z	Ends configuration mode and returns to exec mode
Ctrl+l	Clears the screen
Up Arrow or Ctrl+p	Scroll backward through command history
Down Arrow or Ctrl+n	Scroll forward through command history

Show Command Modifiers

You can use two tokens to modify the output of a `show` command. Enter a question mark to display these tokens:

```
# show users ?
  | Output modifiers
  > Output redirection
```

You can type the | (vertical bar character) to use output modifiers. For example:

```
> show rsvp | ?
begin      Begin with the line that matches
exclude    Exclude lines that match
include    Include lines that match
last       Last few lines
redirect   Redirect output
```

Begin Modifier

The `begin` modifier displays the output beginning with the first line that contains the input string (everything typed after the `begin` keyword). For example:

```
# show running-config | begin xe1
...skipping
interface xe1
  ipv6 address fe80::204:75ff:fee6:5393/64
!
interface xe2
  ipv6 address fe80::20d:56ff:fe96:725a/64
!
line con 0
  login
!
end
```

You can specify a regular expression after the `begin` keyword. This example begins the output at a line with either “xe2” or “xe4”:

```
# show running-config | begin xe[2-4]

...skipping
```

```

interface xe2
 shutdown
!
interface xe4
 shutdown
!
interface svlan0.1
 no shutdown
!
route-map myroute permit 2
!
route-map mymap1 permit 10
!
route-map rmap1 permit 2
!
line con 0
 login
line vty 0 4
 login
!
end

```

Include Modifier

The `include` modifier includes only those lines of output that contain the input string. In the output below, all lines containing the word “input” are included:

```

# show interface xe1 | include input
input packets 80434552, bytes 2147483647, dropped 0, multicast packets 0
input errors 0, length 0, overrun 0, CRC 0, frame 0, fifo 1, missed 0

```

You can specify a regular expression after the `include` keyword. This examples includes all lines with “input” or “output”:

```

#show interface xe0 | include (in|out)put
input packets 597058, bytes 338081476, dropped 0, multicast packets 0
input errors 0, length 0, overrun 0, CRC 0, frame 0, fifo 0, missed 0
output packets 613147, bytes 126055987, dropped 0
output errors 0, aborted 0, carrier 0, fifo 0, heartbeat 0, window 0

```

Exclude Modifier

The `exclude` modifier excludes all lines of output that contain the input string. In the following output example, all lines containing the word “input” are excluded:

```

# show interface xe1 | exclude input
Interface xe1
Scope: both
Hardware is Ethernet, address is 0004.75e6.5393
index 3 metric 1 mtu 1500 <UP,BROADCAST,RUNNING,MULTICAST>
VRF Binding: Not bound
Administrative Group(s): None
DSTE Bandwidth Constraint Mode is MAM
inet6 fe80::204:75ff:fee6:5393/64
output packets 4438, bytes 394940, dropped 0
output errors 0, aborted 0, carrier 0, fifo 0, heartbeat 0, window 0
collisions 0

```

You can specify a regular expression after the `exclude` keyword. This example excludes lines with “output” or “input”:

```
# show interface xe0 | exclude (in|out)put
Interface xe0
  Scope: both
  Hardware is Ethernet   Current HW addr: 001b.2139.6c4a
  Physical:001b.2139.6c4a Logical:(not set)
  index 2 metric 1 mtu 1500 duplex-full arp ageing timeout 3000
  <UP,BROADCAST,RUNNING,MULTICAST>
  VRF Binding: Not bound
  Bandwidth 100m
  DHCP client is disabled.
  inet 10.1.2.173/24 broadcast 10.1.2.255
  VRRP Master of :   VRRP is not configured on this interface.
  inet6 fe80::21b:21ff:fe39:6c4a/64
  collisions 0
```

Redirect Modifier

The `redirect` modifier writes the output into a file. The output is not displayed.

```
# show cli history | redirect /var/frame.txt
```

The output redirection token (`>`) does the same thing:

```
# show cli history >/var/frame.txt
```

Last Modifier

The `last` modifier displays the output of last few number of lines (As per the user input). The last number ranges from 1 to 9999.

For example:

```
#show running-config | last 10
```

String Parameters

The restrictions in [Table P-6](#) apply for all string parameters used in OcNOS commands, unless some other restrictions are noted for a particular command.

Table P-6: String parameter restrictions

Restriction	Description
Input length	1965 characters or less
Restricted special characters	"?", ",", ">", " ", and "=" The " " character is allowed only for the <code>description</code> command in interface mode.

Command Modes

Commands are grouped into modes arranged in a hierarchy. Each mode has its own set of commands. [Table P-7](#) lists the command modes common to all protocols.

Table P-7: Common command modes

Name	Description
Executive mode	Also called <i>view</i> mode, this is the first mode to appear after you start the CLI. It is a base mode from where you can perform basic commands such as <code>show</code> , <code>exit</code> , <code>quit</code> , <code>help</code> , and <code>enable</code> .
Privileged executive mode	Also called <i>enable</i> mode, in this mode you can run additional basic commands such as <code>debug</code> , <code>write</code> , and <code>show</code> .
Configure mode	Also called <i>configure terminal</i> mode, in this mode you can run configuration commands and go into other modes such as interface, router, route map, key chain, and address family. Configure mode is single user. Only one user at a time can be in configure mode.
Interface mode	In this mode you can configure protocol-specific settings for a particular interface. Any setting you configure in this mode overrides a setting configured in router mode.
Router mode	This mode is used to configure router-specific settings for a protocol such as BGP or OSPF.

Command Mode Tree

The diagram below shows the common command mode hierarchy.

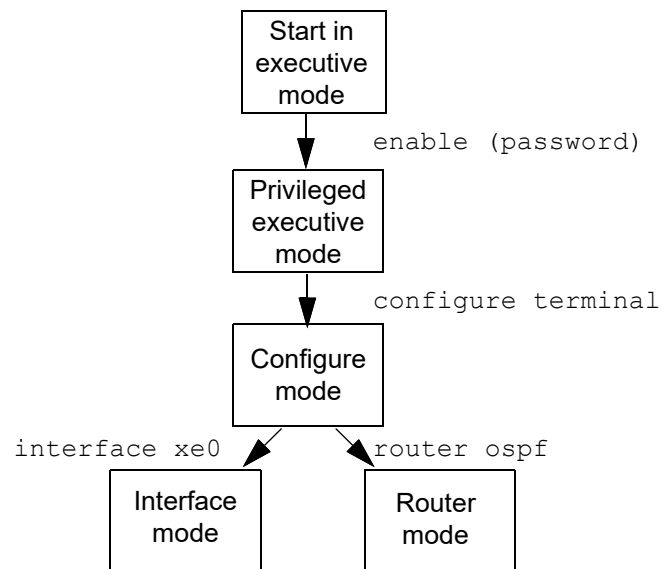


Figure P-1: Common command modes

To change modes:

1. Enter privileged executive mode by entering `enable` in Executive mode.
2. Enter configure mode by entering `configure terminal` in Privileged Executive mode.

The example below shows moving from executive mode to privileged executive mode to configure mode and finally to router mode:

```
> enable mypassword
# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
(config)# router ospf
(config-router)#
```

Note: Each protocol can have modes in addition to the common command modes. See the command reference for the respective protocol for details.

Transaction-based Command-line Interface

The OcNOS command line interface is transaction based:

- Any changes done in configure mode are stored in a separate *candidate* configuration that you can view with the `show transaction current` command.
- When a configuration is complete, apply the candidate configuration to the running configuration with the `commit` command.
- If a `commit` fails, no configuration is applied as the entire transaction is considered failed. You can continue to change the candidate configuration and then retry the `commit`.
- Discard the candidate configuration with the `abort transaction` command.
- Check the last aborted transaction with the `show transaction last-aborted` command.
- Multiple configurations cannot be removed with a single `commit`. You must remove each configuration followed by a `commit`.

Note: All commands MUST be executed only in the default CML shell (`cmlsh`). If you log in as root and start `imish`, then the system configurations will go out of sync. The `imish` shell is not supported and should not be started manually.

Ethernet Virtual Private Network Configuration

CHAPTER 1 EVPN MPLS Configuration

This chapter includes step-by-step configurations for EVPN MPLS for Single Homing and Multi Homing.

Overview

Ethernet VPN (EVPN) solution provides Ethernet multipoint services over MPLS networks. EVPN operates in contrast to the existing Virtual Private LAN Service (VPLS) by enabling control-plane based MAC learning. PEs participating in the EVPN instances learn customer MAC routes in control-plane using MP-BGP protocol. Control-plane MAC learning brings a number of benefits that allow EVPN to address the VPLS shortcomings, including support for multi-homing with per-flow load balancing.

In EVPN, PEs advertise the MAC addresses learned from the CEs that are connected to them, along with an MPLS label, to other PEs in the control plane using Multiprotocol BGP (MP-BGP). Control-plane learning enables load balancing of traffic to and from CEs that are multihomed to multiple PEs. This is in addition to load balancing across the MPLS core via multiple LSPs between the same pair of PEs. It also improves convergence times in the event of certain network failures.

Note: The EVPN will supported over static LSP, LDP,BGP-LU transports.

VPN Terminology

MAC-VRF: A virtual routing and forwarding table for storing MACs on a PE for specific bridge domain.

CE: Customer Edge device, e.g., a host, router, or switch.

PE: Provider edge device

EVI: An EVPN instance spanning the Provider Edge (PE) devices participating in that EVPN.

Note: Ethernet Segment (ES): Set of Ethernet links connected between CE and PE. Single CE can be connected to multiple PEs.

Ethernet Segment Identifier (ESI): A unique non-zero identifier that identifies an Ethernet segment is called an ESI

Ethernet Tag: An Ethernet tag identifies a particular broadcast domain, e.g., a VLAN. An EVPN instance consists of one or more broadcast domains.

Benefits

The EVPN control-plane MAC learning has the following benefits:

- Eliminate flood and learn mechanism as hosts are learned over control plane.
- OcNOS supports both dynamically learned hosts and statically configured hosts, which are advertised/learned over the EVPN control plane.
- Fast-reroute, resiliency, and faster convergence in case of multihoming
- Load balancing of traffic to and from CEs that are multihomed to multiple PE's.

The following EVPN types are supported:

- Single-homed CE: One CE is connected to One PE device.
- Multihomed CE: One CE is connected to Multiple PE devices. OcNOS supports dual-homed CEs with all- active multi homing mode.

Route Types

These EVPN route types are supported:

- Route Type 1: Ethernet Auto-Discovery (AD) Route

The Ethernet (AD) routes are advertised on per EVI and per ESI basis. These routes are sent per ES. They carry the list of EVIs that belong to the ES.

This route is advertised when multihomed CEs already exist.

- Route Type 2: MAC/IP Advertisement Route

The host's IP and MAC addresses are advertised to the peers within NLRI. The control plane learning of MAC addresses reduces unknown unicast flooding.

- Route Type 3: Inclusive Multicast Ethernet Tag Route

This route establishes the connection for broadcast, unknown unicast, and multicast (BUM) traffic from a source PE to a remote PE.

This route is advertised on per VLAN and per ESI basis.

- Route Type 4: Ethernet Segment Route

Ethernet segment routes enable to connect a CE device to two or PE devices.

Ethernet segment routes enable the discovery of connected PE devices that are connected to the same Ethernet segment.

EVPN auto route target will be supported under MAC VRF.

In EVPN-VPWS the auto-discovery of peer PE nodes is done with the pair of Ethernet A-D routes. Inclusive Multicast route does not have participation on auto-discovery unlike ELAN-EVPN VPLS. Since there is no mac-advertisement, MAC-IP route is not applicable

Note: Only Sub-interface supported as Access-port for EVPN-MPLS.

EVPN MPLS Single Homing

Topology

Figure 1-1 depicts the Single Homed topology for the EVPN MPLS configuration examples for both ELINE and ELAN service with LDP as underlay MPLS path.

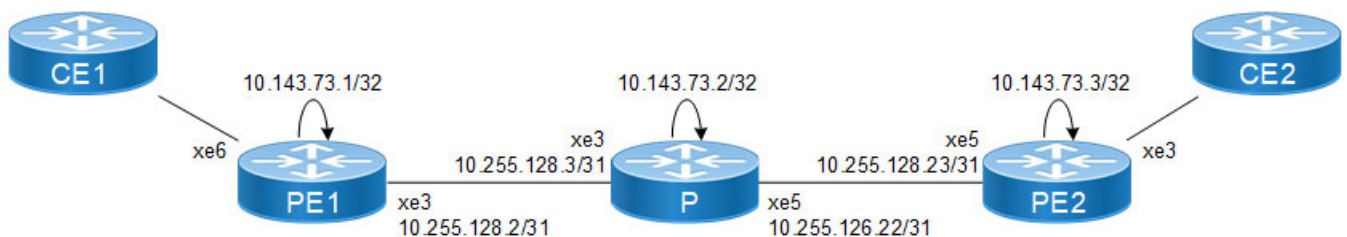


Figure 1-1: EVPN MPLS Single Homing configuration

PE1: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.1/32 secondary	Configure IP address on loopback interface.
(config-if)#commit	Commit the transaction.
(config-if)#exit	Exit interface mode

PE1: Global EVPN MPLS Command

#configure terminal	Enter configuration mode.
(config)#evpn mpls enable	Enable EVPN MPLS
(config)#evpn mpls vtep-ip-global 10.143.73.1	Configuring VTEP global IP to loopback IP
(config)#commit	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature.

PE1: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.1	Set the router ID to IP address 10.143.73.1
(config-router)#transport-address ipv4 10.143.73.1	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 10.143.73.3	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

PE1: Interface Configuration Network Side

(config)#interface xe3	Enter the Interface mode for eth2.
(config-if)#ip address 10.255.128.8/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

Note: For RSVP Configuration refer [RSVP-TE Configuration](#)

PE1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.1	Router-ID configurations
(config-router)#network 10.143.73.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.8/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

PE1: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.3 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.3 update-source lo	Source of routing updates as loopback
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the transaction.

PE1: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.1:2	Configuring Route-Distinguisher value 10.143.73.1:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2
(config-vrf)#exit	Exiting VRF Mode

PE1: MAC VRF Configuration with Auto route target

(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.1:1001	Configuring Route-Distinguisher value 10.143.73.1:1001
(config-vrf)#route-target both evpn-auto-rt	Configuring import and export value as evpn-auto-rt. Route target will be derived automatically.
	Support: route-target export route-target import
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit the transaction.

PE1: EVPN and MAC VRF Mapping

(config)#evpn mpls id 2 xconnect target-mpls-id 252	Configure the EVPN-VPWS identifier with source identifier 2 and target identifier 252
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 1001	Configure the EVPN-VPLS identifier with identifier 1001
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration

(config)#interface xe6	Enter the Interface mode for xe6.
(config-if)#interface xe6.2 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#encapsulation dot1q 2	Setting Encapsulation to dot1q with VLAN ID 2 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 2	Map vpn-id 2 to interface xe6.2 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface xe6.1001 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#encapsulation dot1q 1001	Setting Encapsulation to dot1q with VLAN ID 1001 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1001	Map vpn-id 1001 to interface xe6.1001 (VPLS)
OcNOS(config-access-if)#commit	Commit candidate configuration to be running configuration

P: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.6/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

P: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.255.128.25	Set the router ID to IP address 10.255.128.25
(config-router)#transport-address ipv4 10.255.128.25	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

P: Interface Configuration

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.9/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.25/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

P: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.6	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.6/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.8/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#network 10.255.128.24/31 area 0.0.0.0	Advertise xe5 network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

PE2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.3/32 secondary	Configure IP address on loopback interface.

(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

PE2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.3	Set the router ID to IP address 10.143.73.3
(config-router)#transport-address ipv4 10.143.73.3	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 10.143.73.1	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit router mode
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

PE2: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature
(config)#evpn mpls vtep-ip-global 10.143.73.3	Configuring VTEP global IP to loopback IP
(config)#commit	Commit the transaction.

Interface Configuration Network Side:

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.24/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

PE2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.3	Router-ID configurations
(config-router)#network 10.143.73.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

PE2: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.1 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config)#commit	Commit the transaction.

PE2: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.3:2	Configuring Route-Distinguisher value 10.143.73.3:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2 Support: route-target export route-target import
(config-vrf)#exit	Exiting VRF Mode

PE2: MAC VRF Configuration with Auto route target

(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.1:1001	Configuring Route-Distinguisher value 10.143.73.1:1001
(config-vrf)#route-target both evpn-auto-rt	Configuring import and export value as evpn-auto-rt. Route target will be derived automatically.
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit the transaction.

PE2: EVPN and VRF Mapping

(config)#evpn mpls id 252 xconnect target-mpls-id 2	Configure the EVPN-ELINE identifier with source identifier 252 and target identifier 2
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-ELINE identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 1001	Configure the EVPN-ELAN identifier with identifier 1001
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-ELAN identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration

(config)#interface xe2	Enter the Interface mode for xe2.
(config-if)#description access-side-int	Giving Interface Description
(config-if)#interface xe2.2 switchport	Creating L2 sub interface of physical interface xe2
(config-if)#encapsulation dot1q 2	Setting Encapsulation to dot1q with VLAN ID 2
	Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 2	Map vpn-id 252 to interface xe2.2 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface xe2.1001 switchport	Creating L2 sub interface of physical interface xe2
(config-if)#encapsulation dot1q 1001	Setting Encapsulation to dot1q with VLAN ID 1001
	Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1001	Map vpn-id 1001 to interface xe2.1001 (VPLS)
(config)#commit	Commit candidate configuration to be running configuration

Validation

PE1: E-LAN

```

PE1#sh mac vrf vpls1001
VRF vpls1001, FIB ID 4098
  Router ID is not set
Interfaces:
VRF vpls1001; default RD 10.143.73.3:1001
  Evpn Auto RT:100:1073742025
Import VPN route-target communities
  Evpn Auto RT:100:1073742025
No import route-map
No export route-map
VPNv4 label allocation mode: per-vrf
VPNv6 label allocation mode: per-vrf
import-vnid: 1001
export-vnid: 1001

```

```

PE1#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source          Destination      Status          Up/Down          Update          evpn-id
=====
10.143.73.1      10.143.73.3     Installed       00:01:03         00:01:03         1001

```

Total number of entries are 1

```

PE1#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
Destination      Status          evpn-id  Network-Intf  Tunnel-Label  Local          Remote
MC-Label  UC-Label  MC-Label  UC-Label
=====
10.143.73.3     Installed      1001      xe3            24320         640            17
640            17

```

Total number of entries are 1

```

PE1#show evpn mpls id 1001
EVPN-MPLS Information
=====

```

Codes: NW - Network Port
AC - Access Port
(u) - Untagged

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-Status	Src-Addr	Dst-Addr
1001	vp1s1001	L2	NW	----	----	----	----	10.143.73.1	10.143.73.3
1001	vp1s1001	--	AC	xe6.1001	---	Single Homed Port	---	----	----

Total number of entries are 2

PE1#show evpn mpls mac-table

EVPN MPLS MAC Entries									
VNID	Interface	VlanId	Inner-VlanId	Mac-Addr	VTEP-IP/ESI	Type	Status	AccessPortDesc	
1001	----	----	----	00ff.2300.0000	10.143.73.3	Dynamic Remote	-----	-----	
1001	----	----	----	0023.1001.0001	10.143.73.3	Dynamic Remote	-----	-----	
1001	xe6.1001	----	----	0045.1001.0001	10.143.73.1	Dynamic Local	-----	-----	
1001	xe6.1001	----	----	0071.1001.0001	10.143.73.1	Dynamic Local	-----	-----	

PE1: E-LINE or VPWS

PE1#show evpn mpls xconnect

EVPN-MPLS Xconnect Info

=====

AC-AC: Local-Cross-connect

AC-NW: Cross-connect to Network

AC-UP: Access-port is up

AC-DN: Access-port is down

NW-UP: Network is up

NW-DN: Network is down

NW-SET: Network and AC both are up

Local		Remote		Connection-Details						
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status	
2	----	1500	252	xe6.2	---	Single Homed Port	---	10.143.73.3	1500	AC-NW NW-SET

Total number of entries are 1

PE1#show evpn mpls xconnect tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	local-evpn-id	remote-evpn-id
10.143.73.1	10.143.73.3	Installed	00:01:10	00:01:10	2	252

Total number of entries are 1

PE1#show evpn mpls xconnect tunnel label

EVPN-MPLS Network tunnel labels

Destination	Status	Local		Remote	Network-Intf	Tunnel-Label	Local		Remote	
		VPWS-ID	VPWS-ID				MC-Label	UC-Label	MC-Label	UC-Label
10.143.73.3	Installed	2	252	xe3		24320	--	16	--	16

Total number of entries are 1

PE1#show evpn mpls xconnect id 2

EVPN-MPLS Xconnect Info

=====

AC-AC: Local-Cross-connect

AC-NW: Cross-connect to Network

AC-UP: Access-port is up

AC-DN: Access-port is down

NW-UP: Network is up

NW-DN: Network is down

NW-SET: Network and AC both are up

Local			Remote	Connection-Details					
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status
2	----	1500	252	xe6.2	--- Single Homed Port ---	10.143.73.3	1500	AC-NW	NW-SET

Total number of entries are 1

PE2: ELAN

PE2#show evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
10.143.73.3	10.143.73.1	Installed	00:04:03	00:04:03	1001

Total number of entries are 1

PE2#show evpn mpls tunnel label

EVPN-MPLS Network tunnel labels

Destination	Status	evpn-id	Network-Intf	Tunnel-Label	Local		Remote	
					MC-Label	UC-Label	MC-Label	UC-Label
10.143.73.1	Installed	1001	xe5	24321	640	17	640	--

Total number of entries are 1

PE2#show evpn mpls id 1001

EVPN-MPLS Information

```

=====
Codes: NW - Network Port
       AC - Access Port
       (u) - Untagged

```

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-Status	Src-Addr	Dst-Addr
1001	vppls1001	L2	NW	----	----	----	----	10.143.73.3	10.143.73.1
1001	vppls1001	--	AC	xe2.1001	--- Single Homed Port ---	----	----	----	----

Total number of entries are 2

PE2#show evpn mpls mac-table

EVPN MPLS MAC Entries									
VNID	Interface	VlanId	Inner-VlanId	Mac-Addr	VTEP-IP/ESI	Type	Status	AccessPortDesc	
1001	----	----	----	0045.1001.0001	10.143.73.1	Dynamic Remote	-----	-----	
1001	----	----	----	0071.1001.0001	10.143.73.1	Dynamic Remote	-----	-----	
1001	xe2.1001	----	----	00ff.2300.0000	10.143.73.3	Dynamic Local	-----	-----	
1001	xe2.1001	----	----	0023.1001.0001	10.143.73.3	Dynamic Local	-----	-----	

PE2: ELINE or VPWS

PE2#show evpn mpls xconnect

EVPN-MPLS Xconnect Info

```

=====
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

```

Local	Remote	Connection-Details
-------	--------	--------------------

```
=====
=====
VPN-ID      EVI-Name      MTU    VPN-ID      Source      Destination      PE-IP      MTU    Type    NW-Status
=====
252         ----         1500   2           xe2.2       --- Single Homed Port --- 10.143.73.1 1500   AC-NW   NW-SET

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
10.143.73.3 10.143.73.1      Installed   00:04:10     00:04:10     252         2

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
Destination      Status      Local      Remote      Network-Intf Tunnel-Label      Local      Remote
=====
10.143.73.1      Installed   252        2           xe5          24321          --        16
                                     MC-Label UC-Label MC-Label UC-Label
                                     -----
                                     --        16

Total number of entries are 1

PE2#show evpn mpls xconnect id 252
EVPN-MPLS Xconnect Info
=====
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local      Remote      Connection-Details
=====
=====
VPN-ID      EVI-Name      MTU    VPN-ID      Source      Destination      PE-IP      MTU    Type    NW-Status
=====
252         ----         1500   2           xe2.2       --- Single Homed Port --- 10.143.73.1 1500   AC-NW   NW-SET

Total number of entries are 1
```

EVPN MPLS Single Homing Over BGP-LU

Topology

depicts the Single Homed topology for the EVPN MPLS configuration examples for both ELINE and ELAN service with BGP-LU as underlay MPLS path which in turn over another underlay of LDP/RSVP/SR MPLS paths.

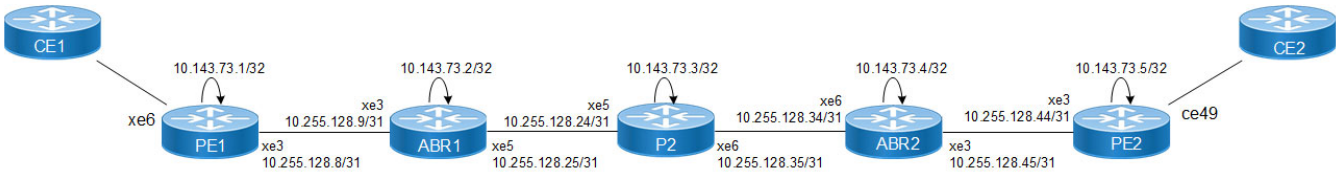


Figure 1-2: EVPN MPLS Single Homing over LU configuration

Configuration

PE1: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.1/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

PE1: Global EVPN MPLS Command

#configure terminal	Enter configuration mode.
(config)#evpn mpls enable	Enable EVPN MPLS
(config)#evpn mpls vtep-ip-global 10.143.73.1	Configuring VTEP global IP to loopback IP
(config)#commit	Commit candidate configuration to be running configuration

PE1: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.1	Set the router ID to IP address 10.143.73.1
(config-router)# transport-address ipv4 10.143.73.1	Configure transport address at LDP mode
(config-router)#targeted-peer ipv4 10.143.73.5	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

PE1: Interface Configuration Network Side

(config)#interface xe3	Enter the Interface mode for eth2.
(config-if)#ip address 10.255.128.8/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

Note: For RSVP Configuration refer [RSVP-TE Configuration](#).

PE1: OSPF Configuration

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.1	Router-ID configurations
(config-router)#network 10.143.73.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.8/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#commit	Commit the transaction.

PE1: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config)#allocate-label all	Configure allocate all under router bgp
(config-router)#neighbor 10.143.73.5 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.2 remote-as 65010	Configuring ABR1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.5 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.2 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into address family ipv4 unicast
(config-router-af)# network 10.143.73.1/32	Advertise 10.143.73.1/31 network
(config-router-af)# exit-address-family	Exit from ipv4 address family
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.2 activate	Activate the ipv4 labeled-unicast neighbor
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.5 activate	Enabling EVPN Address family for neighbor
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

PE1: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.1:2	Configuring Route-Distinguisher value 10.143.73.1:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2 Support: route-target export route-target import
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.1:1001	Configuring Route-Distinguisher value 10.143.73.1:1001

(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001 Support: route-target export Support: route-target export
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

PE1: EVPN and MAC VRF Mapping

(config)#evpn mpls id 2 xconnect target-mpls-id 252	Configure the EVPN-VPWS identifier with source identifier 2 and target identifier 252
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 1001	Configure the EVPN-VPLS identifier with identifier 1001
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration

(config)#interface xe6	Enter the Interface mode for xe6.
(config-if)#description access-side-int	Giving Interface Description
(config-if)#interface xe6.2 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#encapsulation dot1q 2	Setting Encapsulation to dot1q with VLAN ID 2 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 2	Map vpn-id 2 to interface xe6.2 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface xe6.1001 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#encapsulation dot1q 1001	Setting Encapsulation to dot1q with VLAN ID 1001 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1001	Map vpn-id 1001 to interface xe6.1001 (VPLS)
(config-access-if)#commit	Commit candidate configuration to be running configuration

ABR1: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.2/32 secondary	Configure IP address on loopback interface.

(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

ABR1: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#transport-address ipv4 10.143.73.2	Configure transport address under router ldp
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

ABR1: Interface Configuration

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.9/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.25/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

ABR1: OSPF Configuration

(config)#enable ext-ospf-multi-inst	Enable multiple-instance capabilit
(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.2	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.2/32 area 0.0.0.0 instance-id 100	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.25/31 area 0.0.0.0	Advertise network address in OSPF.
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 10.143.73.2/32 area 0.0.0.0 instance-id 1	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.9/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

ABR1: BGP-LU Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config)#allocate-label all	Configure allocate all under router bgp
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.4 remote-as 65010	Configuring ABR2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into address family ipv4 unicast
(config-router-af)# network 10.143.73.2/32	Advertise the network
(config-router-af)# exit-address-family	Exit from ipv4 address family
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.4 activate	Activate the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.4 next-hop-self	Configure next-hopself for the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.4 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.1 activate	Activate the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.1 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.1 next-hop-self	Configure next-hopself for the ipv4 labeled-unicast neighbor
(config)#commit	Commit candidate configuration to be running configuration

P2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.3/32 secondary	Configure IP address on loopback interface.
(config-f)#commit	Commit the transaction.

P2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#commit	Commit the transaction.

P2: Interface Configuration

(config)#interface xe5	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.24/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe6	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.35/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#commit	Commit the transaction.

P2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.3	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#network 10.255.128.35/31 area 0.0.0.0	Advertise xe5 network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

ABR2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.4/32 secondary	Configure IP address on loopback interface.
(config-if)#commit	Commit the transaction.

ABR2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#transport-address ipv4 10.143.73.4	Configure transport address under router ldp
(config)#commit	Commit the transaction.

ABR2: Interface Configuration

(config)#interface xe6	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.34/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe3	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.45/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#commit	Commit the transaction.

ABR2: OSPF Configuration

(config)#enable ext-ospf-multi-inst	Enable multiple-instance capabilit
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.4	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.4/32 area 0.0.0.0 instance-id 200	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.34/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config)#router ospf 200	Enter the Router OSPF mode.
(config-router)#network 10.255.128.45/31 area 0.0.0.0 instance-id 100	Advertise xe5 network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

ABR2: BGP-LU Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config)#allocate-label all	Configure allocate all under router bgp
(config-router)#neighbor 10.143.73.2 remote-as 65010	Configuring ABR1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.5 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.2 update-source lo	Source of routing updates as loopback

(config-router)#neighbor 10.143.73.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into address family ipv4 unicast
(config-router-af)# network 10.143.73.4/32	Advertise the network
(config-router-af)# exit-address-family	Exit from ipv4 address family
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.2 activate	Activate the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.2 next-hop-self	Configure next-hop-self for the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.2 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.5 activate	Activate the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.5 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.5 next-hop-self	Configure next-hop-self for the ipv4 labeled-unicast neighbor
(config-router-af)#commit	Commit the transaction.

PE2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.5/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

PE2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.5	Set the router ID to IP address 10.143.73.5
(config-router)#transport-address ipv4 10.143.73.5	Configure transport address under router ldp
(config-router)#targeted-peer ipv4 10.143.73.3	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#commit	Commit the transaction.

PE2: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature

(config)#evpn mpls vtep-ip-global 10.143.73.5	Configuring VTEP global IP to loopback IP
(config)#commit	Commit the transaction.

PE2: Interface Configuration Network Side

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.44/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-router)#commit	Commit the transaction.

PE2: OSPF Configuration

(config)#router ospf 200	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.5	Router-ID configurations
(config-router)#network 10.143.73.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.44/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#commit	Commit the transaction.

PE2: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config)#allocate-label all	Configure allocate all under router bgp
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.4 remote-as 65010	Configuring ABR2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into address family ipv4 unicast
(config-router-af)# network 10.143.73.5/32	Advertise the network
(config-router-af)# exit-address-family	Exit from ipv4 address family
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.4 activate	Activate the ipv4 labeled-unicast neighbor
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.1 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the transaction.

PE2: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.5:2	Configuring Route-Distinguisher value 10.143.73.3:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2 Support: route-target export route-target import
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.5:1001	Configuring Route-Distinguisher value 10.143.73.3:1001
(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001
(config-vrf)#commit	Commit the transaction.

PE2: EVPN and VRF Mapping

(config)#evpn mpls id 252 xconnect target-mpls-id 2	Configure the EVPN-ELINE identifier with source identifier 252 and target identifier 2
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-ELINE identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 1001	Configure the EVPN-ELAN identifier with identifier 1001
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-ELAN identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration

(config)#interface xe2	Enter the Interface mode for xe2.
(config-if)#description access-side-int	Giving Interface Description
(config-if)#interface xe2.2 switchport	Creating L2 sub interface of physical interface xe2
(config-if)#encapsulation dot1q 2	Setting Encapsulation to dot1q with VLAN ID 2 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 252	Map vpn-id 252 to interface xe2.2 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface xe2.1001 switchport	Creating L2 sub interface of physical interface xe2
(config-if)#encapsulation dot1q 1001	Setting Encapsulation to dot1q with VLAN ID 1001 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1001	Map vpn-id 1001 to interface xe2.1001 (VPLS)
(config)#commit	Commit candidate configuration to be running configuration

Validation

PE1: E-LAN

```
PE1#show evpn mpls tunnel
```

```
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	evpn-id
10.143.73.1	10.143.73.5	Installed	00:01:03	00:01:03	1001

```
Total number of entries are 1
```

```
PE1#sh evpn mpls tunnel label
```

```
EVPN-MPLS Network tunnel labels
```

```
(*) in Policy - tunnel-policy inherited from mac-vrf
```

Destination	Status	VPN-ID	Policy	Local MC-Label	Local UC-Label	Remote MC-Label	Remote UC-Label	RSVP-Multipath Grp-Name	NHLFE-ix	Underlay NW-Intf
10.143.73.5 24325	Installed	1001	--	640	17	640	--	--	--	xe3

```
Total number of entries are 1
```

```
PE1#show evpn mpls id 1001
```

```
EVPN-MPLS Information
```

```
Codes: NW - Network Port
        AC - Access Port
        (u) - Untagged
```

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-Status	Src-Addr	Dst-Addr
1001	vpls1001	L2	NW	----	----	----	----	10.143.73.1	10.143.73.5
1001	vpls1001	--	AC	xe6.1001	---	Single Homed Port	---	----	----

```
Total number of entries are 2
```

```
PE1#sh mpls forwarding-table | inc 10.143.73.5
```

B>	10.143.73.5/32	6	10	-	-	LSP_DEFAULT	24960	xe3	No	10.143.73.2
----	----------------	---	----	---	---	-------------	-------	-----	----	-------------

```
PE1#sh ip bgp labeled-unicast
```

```
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal, S - stale
```

Network	Next Hop	In Label	Out Label
*> 10.143.73.1/32	0.0.0.0	24320	-
*>i 10.143.73.2/32	10.143.73.2	24322	24961
*>i 10.143.73.4/32	10.143.73.2	24323	24963
*>i 10.143.73.5/32	10.143.73.2	24321	24960

```
PE1#
```

```
PE1#show evpn mpls mac-table
```

EVPN MPLS MAC Entries									
VNID	Interface	VlanId	Inner-VlanId	Mac-Addr	VTEP-IP/ESI	Type	Status	AccessPort	Desc
1001	----	----	----	00ff.2300.0000	10.143.73.5	Dynamic Remote	-----	-----	
1001	----	----	----	0023.1001.0001	10.143.73.5	Dynamic Remote	-----	-----	
1001	xe6.1001	----	----	0045.1001.0001	10.143.73.1	Dynamic Local	-----	-----	
1001	xe6.1001	----	----	0071.1001.0001	10.143.73.1	Dynamic Local	-----	-----	

PE1: E-LINE or VPWS

```
PE1#show evpn mpls xconnect
```

EVPN-MPLS Xconnect Info

=====

AC-AC: Local-Cross-connect
 AC-NW: Cross-connect to Network
 AC-UP: Access-port is up
 AC-DN: Access-port is down
 NW-UP: Network is up
 NW-DN: Network is down
 NW-SET: Network and AC both are up

Local			Remote	Connection-Details						
=====			=====	=====						
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status	
=====			=====	=====						
2	----	1500	252	xe6.2	--- Single Homed Port ---	10.143.73.5	1500	AC-NW	NW-SET	

Total number of entries are 1

PE1#show evpn mpls xconnect tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	local-evpn-id	remote-evpn-id
=====						
10.143.73.1	10.143.73.5	Installed	00:01:10	00:01:10	2	252

Total number of entries are 1

PE1#show evpn mpls xconnect tunnel label

EVPN-MPLS Network tunnel labels

(*) in Policy - tunnel-policy inherited from mac-vrf

=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====											
=====											
Destination Label	Status	Local VPWS-ID	Remote VPWS-ID	Policy	Local UC-Label	Remote UC-Label	RSVP-Multipath Grp-Name	NHLFE-ix	NW-Intf	Underlay NW-	
=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====											
10.143.73.5	Installed	2	252	--	16	16	--	--	xe3	24325	

Total number of entries are 1

PE1#sh mpls forwarding-table | inc 10.143.73.5

```
B> 10.143.73.5/32      6          10      -          -      LSP_DEFAULT  24960      xe3          No      10.143.73.2
```

PE1#sh ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal, S - stale

Network	Next Hop	In Label	Out Label
*> 10.143.73.1/32	0.0.0.0	24320	-
*>i 10.143.73.2/32	10.143.73.2	24322	24961
*>i 10.143.73.4/32	10.143.73.2	24323	24963
*>i 10.143.73.5/32	10.143.73.2	24321	24960

PE1#show evpn mpls xconnect id 2

EVPN-MPLS Xconnect Info

=====

AC-AC: Local-Cross-connect
 AC-NW: Cross-connect to Network
 AC-UP: Access-port is up
 AC-DN: Access-port is down
 NW-UP: Network is up
 NW-DN: Network is down
 NW-SET: Network and AC both are up

Local			Remote	Connection-Details						
=====			=====	=====						
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status	
=====			=====	=====						
2	----	1500	252	xe6.2	--- Single Homed Port ---	10.143.73.5	1500	AC-NW	NW-SET	

Total number of entries are 1

PE2: ELAN

```
PE2#show evpn mpls tunnel
```

```
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	evpn-id
10.143.73.5	10.143.73.1	Installed	00:04:03	00:04:03	1001

```
Total number of entries are 1
```

```
PE2#show evpn mpls tunnel label
```

```
EVPN-MPLS Network tunnel labels
```

```
(*) in Policy - tunnel-policy inherited from mac-vrf
```

Destination NW-Label	Status	VPN-ID	Policy	Local		Remote		RSVP-Multipath		Underlay NW-Intf
				MC-Label	UC-Label	MC-Label	UC-Label	Grp-Name	NHLFE-ix	
10.143.73.1 24321	Installed	1001	--	640	17	640	--	--	--	xe3

```
Total number of entries are 1
```

```
PE2#
```

```
PE2#sh mpls forwarding-table | include 10.143.73.1/32
```

B>	10.143.73.1/32	1	1	-	-	LSP_DEFAULT	24961	xe5	No	10.143.73.4
----	----------------	---	---	---	---	-------------	-------	-----	----	-------------

```
PE2#sh ip bgp labeled-unicast
```

```
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal, S - stale
```

Network	Next Hop	In Label	Out Label
*>i 10.143.73.1/32	10.143.73.4	24321	24961
*>i 10.143.73.2/32	10.143.73.4	24323	24963
*>i 10.143.73.4/32	10.143.73.4	24322	24960
*> 10.143.73.5/32	0.0.0.0	24320	-

```
PE2#show evpn mpls id 1001
```

```
EVPN-MPLS Information
```

```
Codes: NW - Network Port
AC - Access Port
(u) - Untagged
```

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-Status	Src-Addr	Dst-Addr
1001	vpls1001	L2	NW	----	----	----	----	10.143.73.5	10.143.73.1
1001	vpls1001	--	AC	xe2.1001	--- Single Homed Port ---	----	----	----	----

```
Total number of entries are 2
```

```
PE2#show evpn mpls mac-table
```

EVPN MPLS MAC Entries									
VNID	Interface	VlanId	Inner-VlanId	Mac-Addr	VTEP-IP/ESI	Type	Status	AccessPort	Desc
1001	----	----	----	0045.1001.0001	10.143.73.1	Dynamic Remote	-----	-----	
1001	----	----	----	0071.1001.0001	10.143.73.1	Dynamic Remote	-----	-----	
1001	xe2.1001	----	----	00ff.2300.0000	10.143.73.5	Dynamic Local	-----	-----	
1001	xe2.1001	----	----	0023.1001.0001	10.143.73.5	Dynamic Local	-----	-----	

PE2: ELINE or VPWS

```
PE2#show evpn mpls xconnect
```

```
EVPN-MPLS Xconnect Info
```

```
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
```

AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local			Remote	Connection-Details					
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status
252	----	1500	2	xe2.2	--- Single Homed Port ---	10.143.73.1	1500	AC-NW	NW-SET

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	local-evpn-id	remote-evpn-id
10.143.73.5	10.143.73.1	Installed	00:04:10	00:04:10	252	2

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel label

EVPN-MPLS Network tunnel labels

		Local		Remote						Local		Remote	
Destination	Status	VPWS-ID	VPWS-ID	Network-Intf	Tunnel-Label	MC-Label	UC-Label	MC-Label	UC-Label	MC-Label	UC-Label	MC-Label	UC-Label
10.143.73.1	Installed	252	2	xe5	24321	--	16	--	16				

Total number of entries are 1

PE2#sh mpls forwarding-table | include 10.143.73.1/32

B> 10.143.73.1/32	1	1	-	-	LSP_DEFAULT	24961	xe5	No	10.143.73.4
-------------------	---	---	---	---	-------------	-------	-----	----	-------------

PE2#sh ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal, S - stale

Network	Next Hop	In Label	Out Label
*>i 10.143.73.1/32	10.143.73.4	24321	24961
*>i 10.143.73.2/32	10.143.73.4	24323	24963
*>i 10.143.73.4/32	10.143.73.4	24322	24960
*> 10.143.73.5/32	0.0.0.0	24320	-

PE2#show evpn mpls xconnect id 252

EVPN-MPLS Xconnect Info

=====

AC-AC: Local-Cross-connect

AC-NW: Cross-connect to Network

AC-UP: Access-port is up

AC-DN: Access-port is down

NW-UP: Network is up

NW-DN: Network is down

NW-SET: Network and AC both are up

Local			Remote	Connection-Details					
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status
252	----	1500	2	xe2.2	--- Single Homed Port ---	10.143.73.1	1500	AC-NW	NW-SET

Total number of entries are 1

EVPN MPLS Multihoming

Topology

The diagram depicts the Multi Homed topology for the EVPN MPLS configuration examples that follow.

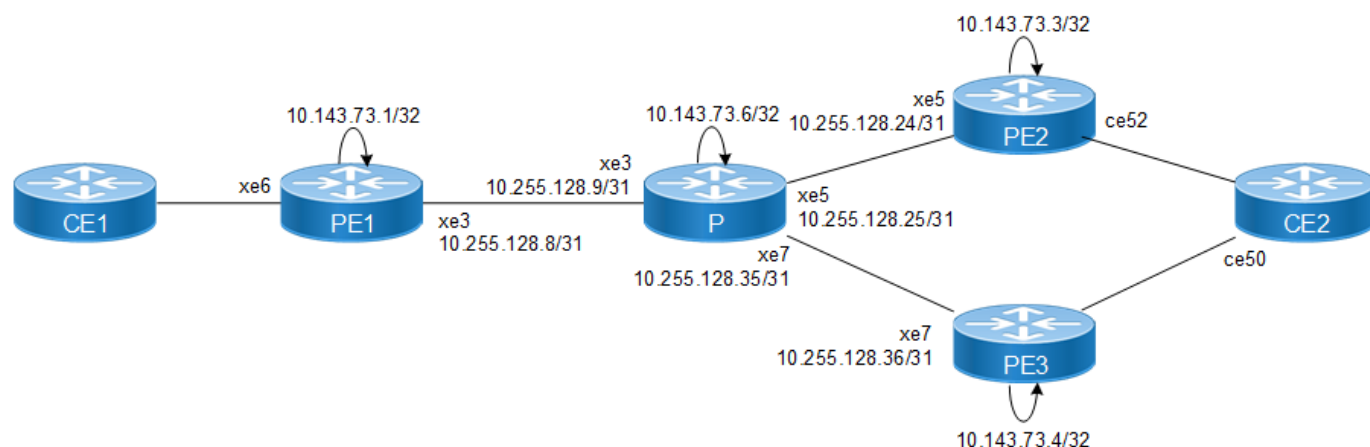


Figure 1-3: MPLS EVPN multi-homing configuration

PE1: Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.1/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config-if)#commit	Commit the transaction.

PE1: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.1	Set the router ID to IP address 10.143.73.1
(config-router)#transport-address ipv4 10.143.73.1	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 10.143.73.3	Configure targeted peer.
(config-router)#targeted-peer ipv4 10.143.73.4	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit from router target peer and LDP mode
(config-router)#commit	Commit the transaction.

PE1: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration
(config)#evpn mpls vtep-ip-global 10.143.73.1	Configuring VTEP global IP to loopback IP
(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter EVPN-MPLS-MH
(config)#evpn mpls multihoming enable	Enable Multihoming
(config)#commit	Commit the transaction.

PE1: Interface Configuration Network Side

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.8/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config-if)#commit	Commit the transaction.

Note: For RSVP Configuration refer [RSVP-TE Configuration](#)

PE1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.1	Router-ID configurations
(config-router)#network 10.143.73.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.8/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

PE1: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.3 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.3 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.4 update-source lo	Source of routing updates as loopback
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN

(config-router-af)#neighbor 10.143.73.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)#neighbor 10.143.73.4 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the transaction.

PE1: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.1:1700	Configuring Route-Distinguisher value 10.143.73.1:1700
(config-vrf)#route-target both 1700:1700	Configuring import and export value as 1700:1700
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.1:1001	Configuring Route-Distinguisher value 10.143.73.1:1001
(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit the transaction.

PE1: EVPN and VRF Mapping

(config)#evpn mpls id 1700 xconnect target-mpls-id 1800	Configure the EVPN-VPWS identifier with source identifier 1700 and target identifier 1800
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier with identifier 3000
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration

(config)#interface xe6	Enter the Interface mode for xe6.
(config-if)#interface xe6.1700 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#description access-side-int	Giving Interface Description
(config-if)#encapsulation dot1q 1700	Setting Encapsulation to dot1q with VLAN ID 1700
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1700	Map vpn-id 1700 to interface xe6.1700 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface xe6.300 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#encapsulation dot1q 3000	Setting Encapsulation to dot1q with VLAN ID 3000

(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 3000	Map vpn-id 3000 to interface xe6.3000 (VPLS)
(config-access-if)#commit	Commit candidate configuration to be running configuration

P: Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.6/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config-if)#commit	Commit the transaction.

P: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.6	Set the router ID to IP address 10.143.73.6
(config-router)#transport-address ipv4 10.143.73.6	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit from router target peer and LDP mode
(config-router)#commit	Commit the transaction.

P: Interface Configuration

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.9/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.25/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface po92	Enter the Interface mode for po92
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#interface xe7	Enter the Interface mode for xe7
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92
(config-if)#interface xe8	Enter the Interface mode for xe8
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92

(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

P: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.6	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.6/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.8/31 area 0.0.0.0	Advertise xe3 network address in OSPF that comes under same subnet
(config-router)#network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#network 10.255.128.36/31 area 0.0.0.0	Advertise po92 network address in OSPF that comes under same subnet
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
OcNOS (config)#commit	Commit candidate configuration to be running configuration

PE2: Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.3/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

PE2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.3	Set the router ID to IP address 10.143.73.3
(config-router)#transport-address ipv4 10.143.73.3	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note:It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 10.143.73.1	Configure targeted peer.
(config-router-targeted-peer)# targeted-peer ipv4 10.143.73.4	Configure targeted peer
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

PE2: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS Note: Reload is required after Enabling/Disabling EVPN MPLS Feature
(config)#commit	Commit candidate configuration to be running configuration
(config)#evpn mpls vtep-ip-global 10.143.73.3	Configuring VTEP global IP to loopback IP
(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter EVPN-MPLS-MH
(config)#evpn mpls multihoming enable	Enable Multihoming
(config)#evpn esi hold-time 60	Delay timer for ESI to come up before enabling evpn
(config)#commit	Commit the transaction.

PE2: Interface Configuration Network Side

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.24/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config-if)#commit	Commit the transaction.

Note: For RSVP Configuration refer [RSVP-TE Configuration](#)

PE2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.3	Router-ID configurations
(config-router)#network 10.143.73.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
OcNOS (config)#commit	Commit candidate configuration to be running configuration

PE2: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.4 update-source lo	Source of routing updates as loopback

(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.1 activate	Enabling EVPN Address family for neighbor
(config-router-af)#neighbor 10.143.73.4 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the transaction.

PE2: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.3:1700	Configuring Route-Distinguisher value 10.143.73.3:1700
(config-vrf)#route-target both 1700:1700	Configuring import and export value as 1700:1700 Support: route-target export route-target import
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.3:1001	Configuring Route-Distinguisher value 10.143.73.3:1001
(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit the transaction.

PE2: EVPN and MAC VRF Mapping

(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with source identifier 1800 and target identifier 1700
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "test" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier with identifier 3000
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration

(config)#interface po90	Enter the Interface mode for po90.
(config-if)#load-interval 30	Load interval setting
(config-if)#evpn multi-homed system-mac 0000.aaaa.bbbc	Configure ESI on a link on which Multi homed CE is connected
(config-if)#interface po90.1700 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 1700	Setting Encapsulation to dot1q with VLAN ID 1700 Supported Encapsulation: dot1ad, dot1q, untagged, default

(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1800	Map vpn-id 2 to interface xe2.2 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface po90.300 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 3000	Setting Encapsulation to dot1q with VLAN ID 3000 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 3000	Map vpn-id 3000 to interface po90.300 (VPLS)
(config-access-if)#exit	Exiting out of Access if mode
(config-if)#interface xe2	Enter the Interface mode for xe2
(config-if)#channel-group 90 mode active	Putting interface xe2 in Dynamic LAG po90
(config)#commit	Commit candidate configuration to be running configuration

PE3: Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.4/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

PE3: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.4	Set the router ID to IP address 10.143.73.4
(config-router)#transport-address ipv4 10.143.73.4	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 10.143.73.1	Configure targeted peer.
(config-router-targeted-peer)# targeted-peer ipv4 10.143.73.3	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit from router LDP mode
(config-router)#commit	Commit the transaction.

PE3: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration
(config)#evpn mpls vtep-ip-global 10.143.73.4	Configuring VTEP global IP to loopback IP

(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter EVPN-MPLS-MH
(config)#evpn mpls multihoming enable	Enable Multihoming
(config)#evpn esi hold-time 60	Delay timer for ESI to come up before enabling evpn
(config)#commit	Commit the transaction.

PE3: Interface Configuration Network Side

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.36/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config-if)#interface xe7	Enter the Interface mode for xe7
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92
(config-if)#interface xe8	Enter the Interface mode for xe8
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

Note: For RSVP Configuration refer [RSVP-TE Configuration](#)

PE3: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.4	Router-ID configurations
(config-router)#network 10.143.73.4/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.36/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

PE3: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.3 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.3 update-source lo	Source of routing updates as loopback
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN

(config-router-af)#neighbor 10.143.73.1 activate	Enabling EVPN Address family for neighbor
(config-router-af)#neighbor 10.143.73.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the transaction.

PE3: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.4:1700	Configuring Route-Distinguisher value 10.143.73.4:1700
(config-vrf)#route-target both 1700:1700	Configuring import and export value as 1700:1700
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.4:1001	Configuring Route-Distinguisher value 10.143.73.4:1001
(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit the transaction.

PE3: EVPN and MAC VRF Mapping

(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with source identifier 1800 and target identifier 1800
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "test" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier with identifier 3000
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE3: Access Port Configuration

(config)#interface po90	Enter the Interface mode for po90.
(config-if)#load-interval 30	Load interval setting
(config-if)#evpn multi-homed system-mac 0000.aaaa.bbbc	Configure ESI on a link on which Multi homed CE is connected
(config-if)#interface po90.1700 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 1700	Setting Encapsulation to dot1q with VLAN ID 1700 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration

(config-access-if)#map vpn-id 1800	Map vpn-id 1800 to Dynamic LAG sub interface po90.1700 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface po90.300 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 3000	Setting Encapsulation to dot1q with VLAN ID 3000 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 3000	Map vpn-id 3000 to interface po90.3000 (VPLS)
(config-access-if)#exit	Exiting out of Access if mode
(config-if)#interface xe2	Enter the Interface mode for xe2
(config-if)#channel-group 90 mode active	Putting interface xe2 in Dynamic LAG po90
(config-if)#commit	Commit candidate configuration to be running configuration

Validation

PE1: ELAN

PE1#show evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
10.143.73.1	10.143.73.4	Installed	00:13:32	00:13:32	3000
10.143.73.1	10.143.73.3	Installed	00:13:33	00:13:33	3000

Total number of entries are 2

PE1#show evpn mpls tunnel label

EVPN-MPLS Network tunnel labels

Destination	Status	evpn-id	Network-Intf	Tunnel-Label	Local		Remote	
					MC-Label	UC-Label	MC-Label	UC-Label
10.143.73.4	Installed	3000	xe3	25601	753	403	654	53
10.143.73.3	Installed	3000	xe3	25600	753	403	753	402

Total number of entries are 2

PE1#show evpn mpls id 3000

EVPN-MPLS Information

```

=====
Codes: NW - Network Port
       AC - Access Port
       (u) - Untagged

```

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-Status	Src-Addr	Dst-Addr
3000	----	L2	NW	----	----	----	----	10.143.73.1	10.143.73.4
3000	----	L2	NW	----	----	----	----	10.143.73.1	10.143.73.3
3000	----	--	AC	xe6.300	--- Single Homed Port ---	----	----	----	----

PE1#show evpn mpls mac-table

EVPN MPLS MAC Entries									
VNID	Interface	VlanId	Inner-VlanId	Mac-Addr	VTEP-IP/ESI	Type	Status	AccessPortDesc	
3000	xe6.300	----	----	0211.2000.03e8	10.143.73.1	Dynamic Local	-----	-----	
3000	xe6.300	----	----	b86a.97cd.6a3d	10.143.73.1	Dynamic Local	-----	-----	
3000	----	----	----	0224.2000.03e8	00:00:00:aa:aa:bb:bc:00:00:00	Dynamic Remote	-----	-----	
3000	----	----	----	b86a.97d2.53bb	00:00:00:aa:aa:bb:bc:00:00:00	Dynamic Remote	-----	-----	

PE1: ELINE or VPWS

```
PE1#show evpn mpls xconnect
```

```
EVPN-MPLS Xconnect Info
```

```
=====
```

```
AC-AC: Local-Cross-connect
```

```
AC-NW: Cross-connect to Network
```

```
AC-UP: Access-port is up
```

```
AC-DN: Access-port is down
```

```
NW-UP: Network is up
```

```
NW-DN: Network is down
```

```
NW-SET: Network and AC both are up
```

Local			Remote	Connection-Details						
=====			=====	=====						
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status	
=====			=====	=====						
1700	----	1500	1800	xe6.1700	00:00:00:aa:aa:bb:bc:00:00:00	10.143.73.4	1500	AC-NW	NW-SET	

```
Total number of entries are 1
```

```
PE1#show evpn mpls xconnect tunnel
```

```
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	local-evpn-id	remote-evpn-id
=====						
10.143.73.1	10.143.73.4	Installed	00:16:50	00:16:50	1700	1800
10.143.73.1	10.143.73.3	Installed	00:16:50	00:16:50	1700	1800

```
Total number of entries are 2
```

```
PE1#show evpn mpls xconnect tunnel label
```

```
EVPN-MPLS Network tunnel labels
```

Destination	Status	Local	Remote	Network-Intf	Tunnel-Label	Local		Remote	
		VPWS-ID	VPWS-ID			MC-Label	UC-Label	MC-Label	UC-Label
=====									
10.143.73.4	Installed	1700	1800	xe3	25601	--	402	--	52
10.143.73.3	Installed	1700	1800	xe3	25600	--	402	--	401

```
Total number of entries are 2
```

```
PE1#show evpn mpls xconnect id 1700
```

```
EVPN-MPLS Xconnect Info
```

```
=====
```

```
AC-AC: Local-Cross-connect
```

```
AC-NW: Cross-connect to Network
```

```
AC-UP: Access-port is up
```

```
AC-DN: Access-port is down
```

```
NW-UP: Network is up
```

```
NW-DN: Network is down
```

```
NW-SET: Network and AC both are up
```

Local			Remote	Connection-Details					
=====			=====	=====					
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status
=====			=====	=====					
1700	----	1500	1800	xe6.1700	00:00:00:aa:aa:bb:bc:00:00:00	10.143.73.3	1500	AC-NW	NW-SET
						10.143.73.4	1500	----	----

```
Total number of entries are 1
```

PE2: VPLS

```
PE2#show evpn mpls tunnel
```

```
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	evpn-id
=====					
10.143.73.3	10.143.73.4	Installed	00:24:41	00:24:41	3000
10.143.73.3	10.143.73.1	Installed	00:24:38	00:24:38	3000

```
Total number of entries are 2
```

```
PE2#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
```

Destination	Status	evpn-id	Network-Intf	Tunnel-Label	Local		Remote	
					MC-Label	UC-Label	MC-Label	UC-Label
10.143.73.4	Installed	3000	xe5	24965	753	402	654	53
10.143.73.1	Installed	3000	xe5	25604	753	402	753	403

Total number of entries are 2

```
PE2#show evpn mpls id 3000
EVPN-MPLS Information
=====
```

```
Codes: NW - Network Port
       AC - Access Port
       (u) - Untagged
```

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-Status	Src-Addr	Dst-Addr
3000	----	L2	NW	----	----	----	----	10.143.73.3	10.143.73.4
3000	----	L2	NW	----	----	----	----	10.143.73.3	10.143.73.1
3000	----	--	AC	po90.300	00:00:00:aa:aa:bb:bc:00:00:00	----	DF	----	----

Total number of entries are 3

```
PE2#show evpn mpls mac-table
```

EVPN MPLS MAC Entries									
VNID	Interface	VlanId	Inner-VlanId	Mac-Addr	VTEP-Ip/ESI	Type	Status	AccessPortDesc	
3000	----	----	----	0211.2000.03e8	10.143.73.1	Dynamic Remote	-----	-----	
3000	----	----	----	b86a.97cd.6a3d	10.143.73.1	Dynamic Remote	-----	-----	
3000	----	----	----	0224.2000.03e8	00:00:00:aa:aa:bb:bc:00:00:00	Dynamic Remote	-----	-----	
3000	po90.300	----	----	b86a.97d2.53bb	00:00:00:aa:aa:bb:bc:00:00:00	Dynamic Local	-----	-----	

PE2: VPWS

```
PE2#show evpn mpls xconnect id 1800
EVPN-MPLS Xconnect Info
=====
```

```
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up
```

Local		Remote		Connection-Details					
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status
1800	----	1500	1700	po90.1700	--- Single Homed Port ---	10.143.73.1	1500	AC-NW	NW-SET

Total number of entries are 1

```
PE2#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	local-evpn-id	remote-evpn-id
10.143.73.3	10.143.73.1	Installed	00:50:18	00:50:18	1800	1700

Total number of entries are 1

```
PE2#show evpn mpls xconnect
EVPN-MPLS Xconnect Info
=====
```

AC-AC: Local-Cross-connect
 AC-NW: Cross-connect to Network
 AC-UP: Access-port is up
 AC-DN: Access-port is down
 NW-UP: Network is up
 NW-DN: Network is down
 NW-SET: Network and AC both are up

Local			Remote		Connection-Details				
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status
1800	----	1500	1700	po90.1700	--- Single Homed Port ---	10.143.73.1	1500	AC-NW	NW-SET

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel label
 EVPN-MPLS Network tunnel labels

Destination	Status	Local		Network-Intf	Tunnel-Label	Local		Remote	
		VPWS-ID	VPWS-ID			MC-Label	UC-Label	MC-Label	UC-Label
10.143.73.1	Installed	1800	1700	xe5	25604	--	401	--	402

Total number of entries are 1

PE3: VPLS

PE3#show evpn mpls tunnel
 EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
10.143.73.4	10.143.73.3	Installed	00:22:11	00:22:11	3000
10.143.73.4	10.143.73.1	Installed	00:22:11	00:22:11	3000

Total number of entries are 2

PE3#show evpn mpls tunnel label
 EVPN-MPLS Network tunnel labels

Destination	Status	evpn-id	Network-Intf	Tunnel-Label	Local		Remote	
					MC-Label	UC-Label	MC-Label	UC-Label
10.143.73.3	Installed	3000	po92	24962	654	53	753	402
10.143.73.1	Installed	3000	po92	24964	654	53	753	403

Total number of entries are 2

PE3#show evpn mpls id 3000
 EVPN-MPLS Information

=====
 Codes: NW - Network Port
 AC - Access Port
 (u) - Untagged

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-Status	Src-Addr	Dst-Addr
3000	----	L2	NW	----	----	----	----	10.143.73.4	10.143.73.3
3000	----	L2	NW	----	----	----	----	10.143.73.4	10.143.73.1
3000	----	--	AC	po90.300	00:00:00:aa:aa:bb:bc:00:00:00	----	NON-DF	----	----

Total number of entries are 3

PE3#show evpn mpls mac-table

EVPN MPLS MAC Entries								
VNID	Interface	VlanId	Inner-VlanId	Mac-Addr	VTEP-IP/ESI	Type	Status	AccessPortDesc
3000	----	----	----	0211.2000.03e8	10.143.73.1	Dynamic Remote	-----	-----


```

3000      ----      ----      ----      b86a.97cd.6a3d 10.143.73.1      Dynamic Remote      -----      -----
3000      ----      ----      ----      0224.2000.03e8 00:00:00:aa:aa:bb:bc:00:00:00      Dynamic Remote      -----      -----
3000      po90.300      ----      ----      b86a.97d2.53bb 00:00:00:aa:aa:bb:bc:00:00:00      Dynamic Local      -----      -----

```

PE3: VPWS

PE3#show evpn mpls xconnect id 1800

EVPN-MPLS Xconnect Info

=====

AC-AC: Local-Cross-connect

AC-NW: Cross-connect to Network

AC-UP: Access-port is up

AC-DN: Access-port is down

NW-UP: Network is up

NW-DN: Network is down

NW-SET: Network and AC both are up

Local			Remote		Connection-Details					
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status	
1800	----	1500	1700	po90.1700	--- Single Homed Port ---	10.143.73.1	1500	AC-NW	NW-SET	

Total number of entries are 1

PE3#show evpn mpls xconnect tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	local-evpn-id	remote-evpn-id
10.143.73.4	10.143.73.1	Installed	00:23:18	00:23:18	1800	1700

Total number of entries are 1

PE3#show evpn mpls xconnect tunnel label

EVPN-MPLS Network tunnel labels

Destination	Status	Local		Remote		Local				Remote	
		VPWS-ID	VPWS-ID	Network-Intf	Tunnel-Label	MC-Label	UC-Label	MC-Label	UC-Label		
10.143.73.1	Installed	1800	1700	po92	24964	--	52	--	402		

Total number of entries are 1

PE3#show evpn mpls xconnect

EVPN-MPLS Xconnect Info

=====

AC-AC: Local-Cross-connect

AC-NW: Cross-connect to Network

AC-UP: Access-port is up

AC-DN: Access-port is down

NW-UP: Network is up

NW-DN: Network is down

NW-SET: Network and AC both are up

Local			Remote		Connection-Details					
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status	
1800	----	1500	1700	po90.1700	--- Single Homed Port ---	10.143.73.1	1500	AC-NW	NW-SET	

Total number of entries are 1

EVPN MPLS Multihoming over BGP-LU

Topology

The diagram depicts the Multi Homed topology for the EVPN MPLS configuration and examples for both ELINE and ELAN service with BGP-LU as underlay MPLS path.

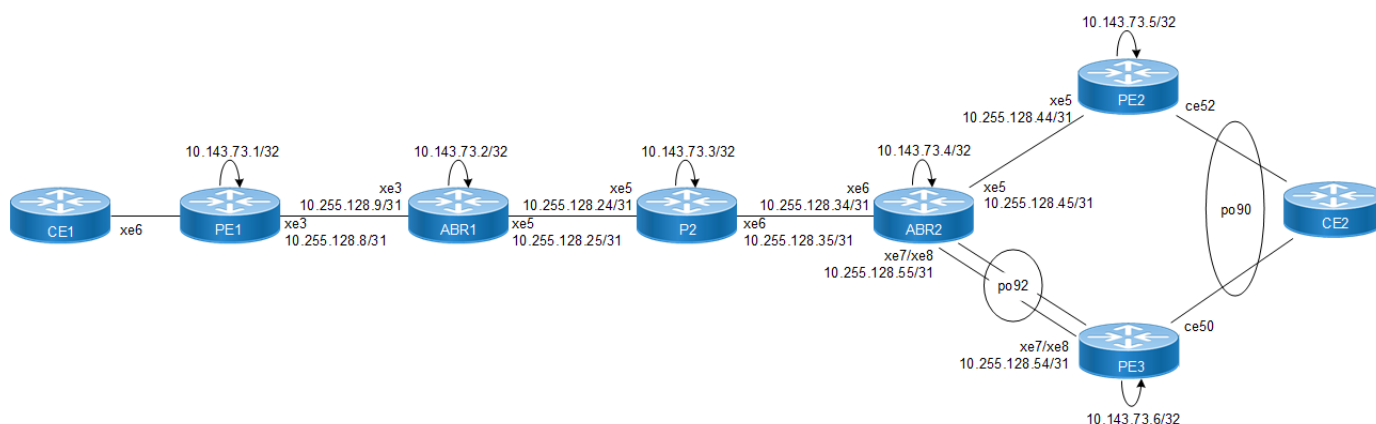


Figure 1-4: MPLS EVPN multi-homing over LU configuration

Configuration

PE1: Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.1/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

PE1: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.1	Set the router ID to IP address 10.143.73.1
(config-router)#transport-address ipv4 10.143.73.1	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router-targeted-peer)# targeted- peer ipv4 10.143.73.6	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

PE1: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration
(config)#evpn mpls vtep-ip-global 10.143.73.1	Configuring VTEP global IP to loopback IP
(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter EVPN-MPLS-MH
(config)#evpn mpls multihoming enable	Enable Multihoming
(config)#commit	Commit the transaction.

PE1: Interface Configuration Network Side

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.8/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

Note: For RSVP Configuration refer [RSVP-TE Configuration](#).

PE1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.1	Router-ID configurations
(config-router)#network 10.143.73.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.8/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

PE1: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.5 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.5 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.6 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.6 update-source lo	Source of routing updates as loopback
(config-router)#address-family 12vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.5 activate	Enabling EVPN Address family for neighbor

(config-router-af)#neighbor 10.143.73.6 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the transaction.

PE1: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.1:1700	Configuring Route-Distinguisher value 10.143.73.1:1700
(config-vrf)#route-target both 1700:1700	Configuring import and export value as 1700:1700
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.1:1001	Configuring Route-Distinguisher value 10.143.73.1:1001
(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit the transaction.

PE1: EVPN and VRF Mapping

(config)#evpn mpls id 1700 xconnect target-mpls-id 1800	Configure the EVPN-VPWS identifier with source identifier 1700 and target identifier 1800
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier with identifier 3000
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit candidate configuration to be running configuration
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration

(config)#interface xe6	Enter the Interface mode for xe6.
(config-if)#interface xe6.1700 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#description access-side-int	Giving Interface Description
(config-if)#encapsulation dot1q 1700	Setting Encapsulation to dot1q with VLAN ID 1700 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1700	Map vpn-id 1700 to interface xe6.1700 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface xe6.300 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#encapsulation dot1q 3000	Setting Encapsulation to dot1q with VLAN ID 3000 Supported Encapsulation: dot1ad, dot1q, untagged, default

(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 3000	Map vpn-id 3000 to interface xe6.3000 (VPLS)
(config-access-if)#commit	Commit candidate configuration to be running configuration

ABR1: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.2/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

ABR1: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.2	Set the router ID to IP address 10.143.73.2
(config-router)#transport-address ipv4 10.143.73.2	Configure transport address under router ldp
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

ABR1: Interface Configuration

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.9/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.25/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

ABR1: OSPF Configuration

(config)#enable ext-ospf-multi-inst	Enable multiple-instance capabilit
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.2	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.2/32 area 0.0.0.0 instance-id 200	Advertise loopback address in OSPF.

(config-router)#network 10.255.128.25/31 area 0.0.0.0	Advertise network address in OSPF.
(config)#router ospf 200	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.2	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.2/32 area 0.0.0.0 instance-id 100	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.9/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

ABR1: BGP-LU Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config)#allocate-label all	Configure allocate all under router bgp
(config-router)#neighbor 10.143.73.1 remote- as 65010	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.4 remote- as 65010	Configuring ABR2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.1 update- source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 update- source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into address family ipv4 unicast
(config-router-af)# network 10.143.73.2/32	Advertise the network
(config-router-af)# exit-address-family	Exit from ipv4 address family
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.4 activate	Activate the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.4 next-hop-self	Configure next-hopself for the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.4 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.1 activate	Activate the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.1 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.1 next-hop-self	Configure next-hopself for the ipv4 labeled-unicast neighbor
(config-router-af)#commit	Commit the transaction.

P2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.

(config-if)#ip address 10.143.73.3/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

P2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.3	Set the router ID to IP address 10.143.73.3
(config-router)#transport-address ipv4 10.143.73.3	Configure transport address under router LDP
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

P2: Interface Configuration

(config)#interface xe5	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.24/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe6	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.35/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

P2: OSPF Configuration

(config)#router ospf 200	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.3	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#network 10.255.128.35/31 area 0.0.0.0	Advertise xe5 network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

ABR2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.

(config-if)#ip address 10.143.73.4/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

ABR2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.4	Set the router ID to IP address 10.143.73.4
(config-router)#transport-address ipv4 10.143.73.4	Configure transport address under router ldp
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

ABR2: Interface Configuration

(config)#interface xe6	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.34/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.45/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface po92	Enter the Interface mode for po92
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#ip address 10.255.128.55/31	Configure IP address on the interface.
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#interface xe7	Enter the Interface mode for xe7
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92
(config-if)#interface xe8	Enter the Interface mode for xe8
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92
(config-if)#commit	Commit the transaction.

ABR2: OSPF Configuration

(config)#enable ext-ospf-multi-inst	Enable multiple-instance capabilit
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.4	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.4/32 area 0.0.0.0 instance-id 300	Advertise loopback address in OSPF.

(config-router)#network 10.255.128.34/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config)#router ospf 300	Enter the Router OSPF mode.
(config-router)#network 10.143.73.4/32 area 0.0.0.0 instance-id 200	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.45/31 area 0.0.0.0	Advertise xe5 network address in OSPF.
(config-router)#network 10.255.128.55/31 area 0.0.0.0	Advertise po network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

ABR2: BGP-LU Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config)#allocate-label all	Configure allocate all under router bgp
(config-router)#neighbor 10.143.73.2 remote-as 65010	Configuring ABR1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.5 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.6 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.2 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.5 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.6 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into address family ipv4 unicast
(config-router-af)# network 10.143.73.4/32	Advertise the network
(config-router-af)# exit-address-family	Exit from ipv4 address family
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.2 activate	Activate the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.2 next-hop-self	Configure next-hop-self for the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.2 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.5 activate	Activate the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.5 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.5 next-hop-self	Configure next-hop-self for the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.6 activate	Activate the ipv4 labeled-unicast neighbor

config-router-af)#neighbor 10.143.73.6 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.6 next-hop-self	Configure next-hop-self for the ipv4 labeled-unicast neighbor
(config-router-af)#commit	Commit candidate configuration to be running configuration

PE2: Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.5/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

PE2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.5	Set the router ID to IP address 10.143.73.5
(config-router)#transport-address ipv4 10.143.73.5	Configure transport address under router ldp
(config-router)#targeted-peer ipv4 10.143.73.1	Configure targeted peer.
(config-router-targeted-peer)# targeted-peer ipv4 10.143.73.6	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

PE2: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS Note: Reload is required after Enabling/Disabling EVPN MPLS Feature
(config)#commit	Commit candidate configuration to be running configuration
(config)#evpn mpls vtep-ip-global 10.143.73.5	Configuring VTEP global IP to loopback IP
(config)#hardware-profile filter evpn-mpls- mh enable	Enable hardware-profile filter EVPN-MPLS-MH
(config)#evpn mpls multihoming enable	Enable Multihoming
(config)#evpn esi hold-time 60	Delay timer for ESI to come up before enabling evpn
(config)#commit	Commit candidate configuration to be running configuration

PE2: Interface Configuration Network Side

(config)#interface xe5	Enter the Interface mode for xe5.
(config-if)#ip address 10.255.128.44/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

Note: For RSVP Configuration refer [RSVP-TE Configuration](#).

PE2: OSPF Configuration

(config)#router ospf 300	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.5	Router-ID configurations
(config-router)#network 10.143.73.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.44/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

PE2: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.4 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.6 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.6 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.4 activate	Activate the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.4 next-hop-self	Configure next-hop-self for the ipv4 labeled-unicast neighbor
(config-router-af)#exit-address-family	Exit the address family
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.1 activate	Enabling EVPN Address family for neighbor

(config-router-af)#neighbor 10.143.73.6 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit candidate configuration to be running configuration

PE2: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.5:1700	Configuring Route-Distinguisher value 10.143.73.5:1700
(config-vrf)#route-target both 1700:1700	Configuring import and export value as 1700:1700
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.5:1001	Configuring Route-Distinguisher value 10.143.73.5:1001
(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit candidate configuration to be running configuration

PE2: EVPN and MAC VRF Mapping

(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with source identifier 1800 and target identifier 1700
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "test" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier with identifier 3000
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit candidate configuration to be running configuration
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration

(config)#interface po90	Enter the Interface mode for po90.
(config-if)#load-interval 30	Load interval setting
(config-if)#evpn multi-homed system-mac 0000.aaaa.bbbc	Configure ESI on a link on which Multi homed CE is connected
(config-if)#interface po90.1700 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 1700	Setting Encapsulation to dot1q with VLAN ID 1700
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1800	Map vpn-id 2 to interface ce49.2 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface po90.300 switchport	Creating L2 sub interface of Dynamic LAG po90

(config-if)#encapsulation dot1q 3000	Setting Encapsulation to dot1q with VLAN ID 3000 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 3000	Map vpn-id 3000 to interface po90.300 (VPLS)
(config-access-if)#exit	Exiting out of Access if mode
(config-if)#interface ce52	Enter the Interface mode for ce52
(config-if)#channel-group 90 mode active	Putting interface ce50 in Dynamic LAG po90
(config)#commit	Commit candidate configuration to be running configuration

PE3: Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.6/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

PE3: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.6	Set the router ID to IP address 10.143.73.5
(config-router)#transport-address ipv4 10.143.73.6	Configure transport address under router ldp
(config-router)#targeted-peer ipv4 10.143.73.1	Configure targeted peer.
(config-router-targeted-peer)# targeted-peer ipv4 10.143.73.5	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit from router LDP mode
(config)#commit	Commit candidate configuration to be running configuration

PE3: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration
(config)#evpn mpls vtep-ip-global 10.143.73.6	Configuring VTEP global IP to loopback IP
(config)#hardware-profile filter evpn-mpls- mh enable	Enable hardware-profile filter EVPN-MPLS-MH
(config)#evpn mpls multihoming enable	Enable Multihoming
(config)#evpn esi hold-time 60	Delay timer for ESI to come up before enabling evpn
(config)#commit	Commit candidate configuration to be running configuration

PE3: Interface Configuration Network Side

(config)#interface po92	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.54/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config-if)#interface xe7	Enter the Interface mode for xe7
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92
(config-if)#interface xe8	Enter the Interface mode for xe8
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

PE3: OSPF Configuration

(config)#router ospf 300	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.6	Router-ID configurations
(config-router)#network 10.143.73.6/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.54/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

PE3: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.4 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.5 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.4 activate	Activate the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.4 next-hop-self	Configure next-hop-self for the ipv4 labeled-unicast neighbor

(config-router-af)#exit-address-family	Exit the address family
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.1 activate	Enabling EVPN Address family for neighbor
(config-router-af)#neighbor 10.143.73.5 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit candidate configuration to be running configuration

PE3: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.6:1700	Configuring Route-Distinguisher value 10.143.73.6:1700
(config-vrf)#route-target both 1700:1700	Configuring import and export value as 1700:1700
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.6:1001	Configuring Route-Distinguisher value 10.143.73.6:1001
(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit candidate configuration to be running configuration

PE3: EVPN and MAC VRF Mapping

(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with source identifier 1800 and target identifier 1800
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "test" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier with identifier 3000
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit candidate configuration to be running configuration
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE3: Access Port Configuration

(config)#interface po90	Enter the Interface mode for po90.
(config-if)#load-interval 30	Load interval setting
(config-if)#evpn multi-homed system-mac 0000.aaaa.bbbc	Configure ESI on a link on which Multi homed CE is connected
(config-if)#interface po90.1700 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 1700	Setting Encapsulation to dot1q with VLAN ID 1700 Supported Encapsulation: dot1ad, dot1q, untagged, default

(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1800	Map vpn-id 1800 to Dynamic LAG sub interface po90.1700 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface po90.300 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 3000	Setting Encapsulation to dot1q with VLAN ID 3000 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 3000	Map vpn-id 3000 to interface po90.3000 (VPLS)
(config-access-if)#exit	Exiting out of Access if mode
(config-if)#interface ce50	Enter the Interface mode for ce50
(config-if)#channel-group 90 mode active	Putting interface ce50 in Dynamic LAG po90
(config)#commit	Commit candidate configuration to be running configuration

Validation

PE1: ELAN

PE1#show evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
10.143.73.1	10.143.73.5	Installed	00:13:32	00:13:32	3000
10.143.73.1	10.143.73.6	Installed	00:13:33	00:13:33	3000

Total number of entries are 2

PE1#show evpn mpls tunnel label

EVPN-MPLS Network tunnel labels

Destination	Status	evpn-id	Network-Intf	Tunnel-Label	Local		Remote	
					MC-Label	UC-Label	MC-Label	UC-Label
10.143.73.5	Installed	3000	xe3	25601	753	403	654	53
10.143.73.6	Installed	3000	xe3	25600	753	403	753	402

Total number of entries are 2

PE1#sh mpls forwarding-table | inc 10.143.73.5

```
B> 10.143.73.5/32      6      10      -      -      LSP_DEFAULT  25601      xe3      No      10.143.73.2
```

PE1#sh mpls forwarding-table | inc 10.143.73.6

```
B> 10.143.73.6/32      6      10      -      -      LSP_DEFAULT  25660      xe3      No      10.143.73.2
```

PE1#sh ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal, S - stale

Network	Next Hop	In Label	Out Label
*> 10.143.73.1/32	0.0.0.0	24320	-
*>i 10.143.73.2/32	10.143.73.2	24322	25603
*>i 10.143.73.4/32	10.143.73.2	24323	25602
*>i 10.143.73.5/32	10.143.73.2	24321	25601
*>i 10.143.73.6/32	10.143.73.2	24324	25600

PE1#show evpn mpls id 3000

EVPN-MPLS Information

```

=====
Codes: NW - Network Port
       AC - Access Port
       (u) - Untagged

```

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-Status	Src-Addr	Dst-Addr
--------	----------	----------	------	-----------	-----	------	-----------	----------	----------


```

3000    ----    L2    NW    ----    ----    ----    ----    10.143.73.1    10.143.73.5
3000    ----    L2    NW    ----    ----    ----    ----    10.143.73.1    10.143.73.6
3000    ----    --    AC    xe6.300    --- Single Homed Port ---    ----    ----    ----    ----

```

PE1#show evpn mpls mac-table

```

=====
                                EVPN MPLS MAC Entries
=====
VNID      Interface VlanId Inner-VlanId Mac-Addr      VTEP-IP/ESI      Type      Status      AccessPortDesc
-----
3000      xe6.300    ----    ----      0211.2000.03e8  10.143.73.1      Dynamic Local  -----      -----
3000      xe6.300    ----    ----      b86a.97cd.6a3d  10.143.73.1      Dynamic Local  -----      -----
3000      ----      ----    ----      0224.2000.03e8  00:00:00:aa:aa:bb:bc:00:00:00  Dynamic Remote  -----      -----
3000      ----      ----    ----      b86a.97d2.53bb  00:00:00:aa:aa:bb:bc:00:00:00  Dynamic Remote  -----      -----

```

PE1: ELINE or VPWS

PE1#show evpn mpls xconnect

EVPN-MPLS Xconnect Info

=====

AC-AC: Local-Cross-connect

AC-NW: Cross-connect to Network

AC-UP: Access-port is up

AC-DN: Access-port is down

NW-UP: Network is up

NW-DN: Network is down

NW-SET: Network and AC both are up

```

Local      Remote      Connection-Details
=====
=====
VPN-ID      EVI-Name      MTU      VPN-ID      Source      Destination      PE-IP      MTU      Type      NW-Status
=====
1700      ----      1500      1800      xe6.1700      00:00:00:aa:aa:bb:bc:00:00:00  10.143.73.5      1500      AC-NW      NW-SET

```

Total number of entries are 1

PE1#show evpn mpls xconnect tunnel

EVPN-MPLS Network tunnel Entries

```

Source      Destination      Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
10.143.73.1    10.143.73.5      Installed    00:16:50      00:16:50      1700      1800
10.143.73.1    10.143.73.6      Installed    00:16:50      00:16:50      1700      1800

```

Total number of entries are 2

PE1#show evpn mpls xconnect tunnel label

EVPN-MPLS Network tunnel labels

```

Destination      Status      Local      Remote      Network-Intf      Tunnel-Label      Local      Remote
VPWS-ID      VPWS-ID      MC-Label      UC-Label      MC-Label      UC-Label
=====
10.143.73.5      Installed    1700      1800      xe3      25601      --      402      --      52
10.143.73.6      Installed    1700      1800      xe3      25600      --      402      --      401

```

Total number of entries are 2

PE1#show evpn mpls xconnect id 1700

EVPN-MPLS Xconnect Info

=====

AC-AC: Local-Cross-connect

AC-NW: Cross-connect to Network

AC-UP: Access-port is up

AC-DN: Access-port is down

NW-UP: Network is up

NW-DN: Network is down

NW-SET: Network and AC both are up

```

Local      Remote      Connection-Details

```

```
=====
```

VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status
1700	----	1500	1800	xe6.1700	00:00:00:aa:aa:bb:bc:00:00:00	10.143.73.5 10.143.73.6	1500 1500	AC-NW ----	NW-SET ----

Total number of entries are 1

PE2: VPLS

```
PE2#show evpn mpls tunnel
```

```
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	evpn-id
10.143.73.5	10.143.73.6	Installed	00:24:41	00:24:41	3000
10.143.73.5	10.143.73.1	Installed	00:24:38	00:24:38	3000

Total number of entries are 2

```
PE2#show evpn mpls tunnel label
```

```
EVPN-MPLS Network tunnel labels
```

Destination	Status	evpn-id	Network-Intf	Tunnel-Label	Local		Remote	
					MC-Label	UC-Label	MC-Label	UC-Label
10.143.73.6	Installed	3000	xe5	24965	753	402	654	53
10.143.73.1	Installed	3000	xe5	25604	753	402	753	403

Total number of entries are 2

```
PE2#show evpn mpls id 3000
```

```
EVPN-MPLS Information
```

```
=====
Codes: NW - Network Port
       AC - Access Port
       (u) - Untagged
```

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-Status	Src-Addr	Dst-Addr
3000	----	L2	NW	----	----	----	----	10.143.73.5	10.143.73.6
3000	----	L2	NW	----	----	----	----	10.143.73.5	10.143.73.1
3000	----	--	AC	po90.300	00:00:00:aa:aa:bb:bc:00:00:00	----	DF	----	----

Total number of entries are 3

```
PE2#show evpn mpls mac-table
```

```
=====
```

EVPN MPLS MAC Entries									
VNID	Interface	VlanId	Inner-VlanId	Mac-Addr	VTEP-IP/ESI	Type	Status	AccessPortDesc	
3000	----	----	----	0211.2000.03e8	10.143.73.1	Dynamic Remote	-----	-----	
3000	----	----	----	b86a.97cd.6a3d	10.143.73.1	Dynamic Remote	-----	-----	
3000	----	----	----	0224.2000.03e8	00:00:00:aa:aa:bb:bc:00:00:00	Dynamic Remote	-----	-----	
3000	po90.300	----	----	b86a.97d2.53bb	00:00:00:aa:aa:bb:bc:00:00:00	Dynamic Local	-----	-----	

PE2: VPWS

```
PE2#show evpn mpls xconnect id 1800
```

```
EVPN-MPLS Xconnect Info
```

```
=====
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up
```

Local	Remote	Connection-Details
-------	--------	--------------------

```

=====
=====
VPN-ID      EVI-Name      MTU   VPN-ID      Source      Destination      PE-IP      MTU   Type   NW-Status
=====
1800        ----          1500  1700        po90.1700    --- Single Homed Port ---  10.143.73.1  1500  AC-NW  NW-SET
=====

```

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel

EVPN-MPLS Network tunnel Entries

```

Source      Destination      Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
10.143.73.5  10.143.73.1      Installed    00:50:18     00:50:18     1800          1700
=====

```

Total number of entries are 1

PE2#show evpn mpls xconnect

EVPN-MPLS Xconnect Info

=====

AC-AC: Local-Cross-connect

AC-NW: Cross-connect to Network

AC-UP: Access-port is up

AC-DN: Access-port is down

NW-UP: Network is up

NW-DN: Network is down

NW-SET: Network and AC both are up

```

Local      Remote      Connection-Details
=====
VPN-ID      EVI-Name      MTU   VPN-ID      Source      Destination      PE-IP      MTU   Type   NW-Status
=====
1800        ----          1500  1700        po90.1700    --- Single Homed Port ---  10.143.73.1  1500  AC-NW  NW-SET
=====

```

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel label

EVPN-MPLS Network tunnel labels

```

Destination      Status      Local      Remote      Network-Intf  Tunnel-Label  MC-Label  Local      Remote
VPWS-ID          VPWS-ID                                     UC-Label  MC-Label  UC-Label
=====
10.143.73.1      Installed    1800      1700        xe5            25604         --         401        --         402
=====

```

Total number of entries are 1

PE3: VPLS:

PE3#show evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

```

Source      Destination      Status      Up/Down      Update      evpn-id
=====
10.143.73.6  10.143.73.5      Installed    00:22:11     00:22:11     3000
10.143.73.6  10.143.73.1      Installed    00:22:11     00:22:11     3000
=====

```

Total number of entries are 2

PE3#show evpn mpls tunnel label

EVPN-MPLS Network tunnel labels

```

Destination      Status      evpn-id  Network-Intf  Tunnel-Label  Local      Remote
MC-Label  UC-Label  MC-Label  UC-Label
=====
10.143.73.5      Installed    3000      po92          24962         654        53        753        402
10.143.73.1      Installed    3000      po92          24964         654        53        753        403
=====

```

Total number of entries are 2

PE3#show evpn mpls id 3000

EVPN-MPLS Information

=====

Codes: NW - Network Port
AC - Access Port
(u) - Untagged

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-Status	Src-Addr	Dst-Addr
3000	----	L2	NW	----	----	----	----	10.143.73.5	10.143.73.6
3000	----	L2	NW	----	----	----	----	10.143.73.5	10.143.73.1
3000	----	--	AC	po90.300	00:00:00:aa:aa:bb:bc:00:00:00	----	NON-DF	----	----

Total number of entries are 3

PE3#show evpn mpls mac-table

EVPN MPLS MAC Entries									
VNID	Interface	VlanId	Inner-VlanId	Mac-Addr	VTEP-IP/ESI	Type	Status	AccessPort	Desc
3000	----	----	----	0211.2000.03e8	10.143.73.1	Dynamic Remote	-----	-----	
3000	----	----	----	b86a.97cd.6a3d	10.143.73.1	Dynamic Remote	-----	-----	
3000	----	----	----	0224.2000.03e8	00:00:00:aa:aa:bb:bc:00:00:00	Dynamic Remote	-----	-----	
3000	po90.300	----	----	b86a.97d2.53bb	00:00:00:aa:aa:bb:bc:00:00:00	Dynamic Local	-----	-----	

PE3: VPWS

PE3#show evpn mpls xconnect id 1800

EVPN-MPLS Xconnect Info

=====

AC-AC: Local-Cross-connect

AC-NW: Cross-connect to Network

AC-UP: Access-port is up

AC-DN: Access-port is down

NW-UP: Network is up

NW-DN: Network is down

NW-SET: Network and AC both are up

Local		Remote		Connection-Details					
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status
1800	----	1500	1700	po90.1700	--- Single Homed Port ---	10.143.73.1	1500	AC-NW	NW-SET

Total number of entries are 1

PE3#show evpn mpls xconnect tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	local-evpn-id	remote-evpn-id
10.143.73.6	10.143.73.1	Installed	00:23:18	00:23:18	1800	1700

Total number of entries are 1

PE3#show evpn mpls xconnect tunnel label

EVPN-MPLS Network tunnel labels

Local		Remote		Local					
Destination	Status	VPWS-ID	VPWS-ID	Network-Intf	Tunnel-Label	MC-Label	UC-Label	MC-Label	UC-Label
10.143.73.1	Installed	1800	1700	po92	24964	--	52	--	402

Total number of entries are 1

PE3#show evpn mpls xconnect

EVPN-MPLS Xconnect Info

=====

AC-AC: Local-Cross-connect

AC-NW: Cross-connect to Network

AC-UP: Access-port is up

AC-DN: Access-port is down
 NW-UP: Network is up
 NW-DN: Network is down
 NW-SET: Network and AC both are up

```

Local                               Remote      Connection-Details
=====
VPN-ID      EVI-Name      MTU  VPN-ID      Source      Destination      PE-IP      MTU  Type  NW-Status
=====
1800        ----        1500  1700        po90.1700    --- Single Homed Port ---  10.143.73.1  1500  AC-NW  NW-SET

Total number of entries are 1

```

EVPN-MPLS L2CP Tunneling

EVPN-MPLS services shall support transparent L2 control plane protocol tunneling via network tunnels between CE's, via Sub-ifp framework support. The protocols which are tunneled are controlled by configuration at parent Interface (of A/C ports). The below list of L2 control plane BPDUs shall be transparently tunneled across EVPN-MPLS networks based on egress tunnels when Tunnel action is configured.

- dot1x
- efm
- elmi
- lldp
- xSTP
- lacp

In case of action "DISCARD" and "PEER" appropriate behavior should see.

- PEER - the corresponding L2 control packet shall be uplifted to the CPU/control plane for processing.
- DISCARD - the corresponding L2 control packets are dropped at node.

Default behavior is PEER.

Topology

See [Figure 1-1](#) and [Figure 1-3](#).

Note: L2CP should be enabled in all PEs access interface to have end to end traffic.

L2CP Configurations

(config)#in xe1	Entering into interface level of access side interface
(config-if)#l2protocol <protocol> tunnel	Enabling tunnel for the L2CP protocol
(config-if)#l2protocol <protocol> peer	Enabling peer for the L2CP protocol
(config-if)#l2protocol <protocol> discard	Enabling discard for the L2CP protocol

Validation

```

PE2#show l2protocol processing interface <interface>
Bridge      Interface Name  Protocol      Processing Status  Hardware Status
=====

```

```

-      xe8      stp      Tunnel      Peer
-      xe8      lacp     Tunnel      Peer
-      xe8      dot1x    Peer        Peer
-      xe8      lldp     Peer        Peer
-      xe8      efm      Discard     Discard
-      xe8      elmi     Discard     Discard
-      xe8      synce    Discard     Discard

```

```
PE3#show l2protocol interface po1 counters
```

```

Interface po1
Peer      : lacp      : 94
Peer      : stp       : 298
Peer      : elmi      : 172
Peer      : dot1x     : 172
Discard   : stp       : 6558
Discard   : elmi      : 8326
Discard   : dot1x     : 9839

```

Note: Tunnel counter won't get incremented as per design.

```
PE4#show interface counters queue-stats
```

```
E - Egress, I - Ingress, Q-Size is in bytes
```

```
* indicates monitor is active
```

Interface	Queue/Class-map	Q-Size	Tx pkts	Tx bytes	Dropped pkts	Dropped bytes
cpu	reserved-mc	(E) 2097152	6	522	0	0
cpu	bgp	(E) 1048576	2	145	0	0
cpu	rsvp-ldp	(E) 1048576	7	1060	0	0
cpu	bpdu	(E) 1048576	6481	4830520	5126	3815132
ge6	q0	(E) 1253376	350	258691	0	0
ge6	q6	(E) 1253376	114	10338	0	0
ge7	q0	(E) 1253376	6	2708	0	0
ge7	q6	(E) 1253376	2	186	0	0
ge8	q0	(E) 1253376	5177	3859861	0	0
xe12	q6	(E) 12517376	6	517	0	0
xe15	q0	(E) 12517376	2	1281	0	0
xe16	q0	(E) 12517376	2253	1694682	0	0

Note: CPU drop counters will increment for both peer and discard as per design.

EVPN-MPLS MAC Statistics

MAC Statistics feature provides statistics based on number of MAC's routes learned during ELAN and ETREE EVPN-MPLS service. Generic show command supported for both MH and SH services.

"show evpn mpls route-count" is used by admin to fetch all the three route type count (MAC-Only, MAC-IPV4, MAC-IPV6) for per VPN-ID of an EVPN MPLS service and/or route-type.

The details of routes can be fetched via "show evpn mpls nd-cache", "show evpn mpls arp-cache" and "show evpn mpls mac table".

MAC Statistics functionality is "Not Applicable" for EVPN E-LINE service as its point-2-point and does not have MAC advertisements functionality.

Topology

See [Figure 1-1](#) and [Figure 1-3](#).

Configurations

Refer to above configurations to bring up the EVPN service for both SH and MH. No specific configuration needed to get the show command output. Based on the installed service and traffic below route count will be fetched.

Validation

```
PE1#show evpn mpls route-count
EVPN-MPLS Active route count information
```

```
=====
```

```
Max route count      : 32768
```

```
Active route count: 51
```

VNID	Total	MACONLY	MACIPv4	MACIPv6
602	17	7	5	5
601	17	7	5	5
801	17	7	5	5
802	0	0	0	0

```
Total number of entries are 4
```

EVPN-MPLS Control-Word Support

A control-word is 4-byte optional field inserted between MPLS label stack & MPLS payload in data traffic as demarcation between MPLS labels & payload to distinguish a PW payload from an IP payload carried over the MPLS LSP, so that LSR or transit node which does deep packet inspection should not treat PW payload as IP payload and result in incorrect ECMP/load-sharing.

Some of salient points for support provided in OcNOS:

- control-word is applicable for both L2-EVPN (E-LAN, E-LINE etc) service data traffics and not applicable for L3-EVPN (IRB) traffic.
- control-word is based on static-CLI configurable along with any EVPN instance creation.

hardware-profile filter evpn-mpls-cw enable CLI must be configured for Control-word Support.

System requires reboot once after hardware profile filter control-word enabled.

Topology

See [Figure 1-1](#) and [Figure 1-3](#).

Note: Control-word should be symmetrically enabled/disabled across all PE nodes to have end to end non-malformed traffic handling.

EVPN-MPLS Control-Word Configurations

Refer to [EVPN MPLS Single Homing](#) configurations to bring up the EVPN service for SH.

PE1: EVPN and MAC VRF Mapping

(config)#hardware-profile filter evpn-mpls-cw enable	Enable hardware profile filter evpn-mpls-cw for Control-word support
(config)#evpn mpls id 2 xconnect target-mpls-id 252 control-word	Configure the EVPN-VPWS identifier with source identifier 2 and target identifier 252 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier

(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 1001 control-word	Configure the EVPN-VPLS identifier with identifier 1001 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: EVPN and VRF Mapping

(config)#hardware-profile filter evpn-mpls-cw enable	Enable hardware profile filter evpn-mpls-cw for Control-word support
(config)#evpn mpls id 252 xconnect target-mpls-id 2 control-word	Configure the EVPN-ELINE identifier with source identifier 252 and target identifier 2 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-ELINE identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 1001 control-word	Configure the EVPN-ELAN identifier with identifier 1001 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-ELAN identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

Refer to [EVPN MPLS Multihoming](#) configurations to bring up the EVPN service for MH.

PE1: EVPN and VRF Mapping

(config)#hardware-profile filter evpn-mpls-cw enable	Enable hardware profile filter evpn-mpls-cw for Control-word support
(config)#evpn mpls id 1700 xconnect target-mpls-id 1800 control-word	Configure the EVPN-VPWS identifier with source identifier 1700 and target identifier 1800 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000 control-word	Configure the EVPN-VPLS identifier with identifier 3000 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: EVPN and MAC VRF Mapping

(config)#hardware-profile filter evpn-mpls-cw enable	Enable hardware profile filter evpn-mpls-cw for Control-word support
(config)#evpn mpls id 1800 xconnect target-mpls-id 1700 control-word	Configure the EVPN-VPWS identifier with source identifier 1800 and target identifier 1700 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "test" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000 control-word	Configure the EVPN-VPLS identifier with identifier 3000 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE3: EVPN and MAC VRF Mapping

(config)#hardware-profile filter evpn-mpls-cw enable	Enable hardware profile filter evpn-mpls-cw for Control-word support
(config)#evpn mpls id 1800 xconnect target-mpls-id 1700 control-word	Configure the EVPN-VPWS identifier with source identifier 1800 and target identifier 1800 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "test" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000 control-word	Configure the EVPN-VPLS identifier with identifier 3000 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

Validation

`show running-config evpn mpls` should display control-word configuration along EVI instance. Traffic validations are performed using packet capture to observe 4-byte control word present in data traffic.

EVPN-MPLS RSVP Multipath

EVPN-MPLS services with RSVP multipath as a transport provides, Multiple RSVP tunnels which are grouped in ECMP/Multipath group to do load sharing for better optimized and efficient usages of multiple RSVP trunks towards the same Destination.

At ingress node the traffic is load-balanced based on the configured hash (L3 src/dest IP/port, L2 src/dst mac, or in-label if intermediate Autonomous segments). Each LSP path within multipath group can provide individual protection for each path (facility, 1-to-1, secondary).

Each tunnel path in multipath group cost may vary (can have different hop, with consideration for load-balancing the traffic).

Unicast traffic is load shared across all the available multipath member (but not mandatory always) where as in case of BUM only the Active member carries traffic. Addition/deletion should not have impact in traffic in case of unicast, and switchover time is not guaranteed <50ms in case of BUM traffic.

This feature supports across all EVPN service as both SH and MH modes and only BUM Traffic not supported for ELINE service alone as per RFC standard.

Topology

See [Figure 1-1](#), [Figure 1-3](#), [Figure 1-5](#).

Multi Path Configurations

See the previous configurations to bring up the EVPN service for both SH and MH. Transport alone we need to change it from LDP/RSVP to RSVP Multipath as per below configurations.

(config)#router rsvp	Creation of RSVP
(config-router)#int xe1	Entering into interface level
(config-if)#enable-rsvp	Associate the configured RSVP to the exit interface.
(config-router)#int xe2	Creation into interface level
(config-if)#enable-rsvp	Associate the configured RSVP to the exit interface.
(Config)#rsvp-multipath MP1	Create an RSVP multipath group 1
(config-multipath)#description To-PE3-SH-ELINE-ELAN-ETREE	RSVP multipath specific description
(config-multipath)#to 7.7.7.7	RSVP multipath destination prefix
(config)# rsvp-path P1_PE3	Path for Resource Reservation Protocol (RSVP) with Name
(config-path)# 10.1.24.2 loose	Configure this explicit route path as a loose or strict hop
(config-path)#exit	Exit Path mode.
(config)# rsvp-path P2_PE3	Path for Resource Reservation Protocol (RSVP) with Name
(config-path)# 10.1.34.2 loose	Configure this explicit route path as a loose or strict hop
(config-path)#exit	Exit Path mode.
(config)#rsvp-trunk T1_PE3	Create an RSVP trunk T1 and enter the Trunk mode.
(config-trunk)#primary path P1_PE3	Specify an RSVP path to be used
(config-trunk)#to 7.7.7.7	Specify the IPv4 egress (destination point) for the LSP
(config-trunk)#multipath-group MP1	Associating the MP member to the RSVP trunk
(config)#rsvp-trunk T2_PE3	Create an RSVP trunk T1 and enter the Trunk mode.
(config-trunk)#primary path P2_PE3	Specify an RSVP path to be used
(config-trunk)#to 7.7.7.7	Specify the IPv4 egress (destination point) for the LSP
(config-trunk)#multipath-group MP1	Associating the MP member to the RSVP trunk
(config-trunk)#exit	Exit trunk mode.
(config)#commit	Commit candidate configuration to be running configuration

VPN-ID	DESTINATION PEER	BUM TX (pkts)	Unicast TX (pkts)
1601	3.3.3.3	264177	0
501	3.3.3.3	0	0
601	3.3.3.3	0	0
1801	3.3.3.3	264312	0
801	3.3.3.3	0	0
1601	8.8.8.8	264439	0
601	8.8.8.8	0	0
1801	8.8.8.8	264440	0
1601	4.4.4.4	264503	0
1501	4.4.4.4	0	0
1801	4.4.4.4	264530	0

EVPN-ELINE CFM Single Homing

CFM (as per IEEE 802.1ag 2007) provides capabilities useful for detecting, verifying and isolating connectivity failures in Virtual Bridged Local Area Networks through Continuity Check, Loop Back and Link Trace protocols. These capabilities can be used in networks operated by multiple independent organizations, each with restricted access to each other's equipment.

The network administrator is generally informed about the failure in the connection based on the reception of Continuity Check Messages or by the user. The administrator can then initiate Loop Back or Link Trace accordingly to quickly determine and then isolate the fault condition.

The CFM information is conveyed in Protocol frames called CFM Protocol Data Units (CFM PDUs). The CFM PDUs contain the appropriate control and status information used to detect, verify and isolate faults. It also contains information for path discovery in CFM-enabled links.

Currently, supported only for EVPN-ELINE Single home and up MEP service on both Q1 and Q2 platforms.

Topology

The diagram depicts the Single Homed topology for the EVPN MPLS configuration examples that follow.

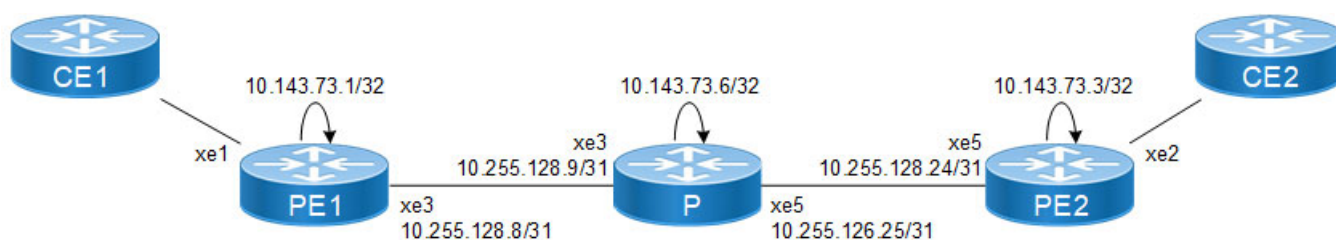


Figure 1-5: EVPN MPLS Single Homing configuration

Prerequisite

Configure below hardware-profile commands related to CFM in configuration mode and reboot the nodes.

```

hardware-profile filter cfm-domain-name-str enable
hardware-profile statistics cfm-ccm enable

```

PE1: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.1/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

PE1: Global EVPN MPLS Command

#configure terminal	Enter configuration mode.
(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature
(config)#evpn mpls vtep-ip-global 10.143.73.1	Configuring VTEP global IP to loopback IP

PE1: Global LDP

(config)#router ldp	Enter the Router LDP mode.
PE1(config-router)#router-id 10.143.73.1	Set the router ID to IP address 10.143.73.1
PE1(config-router)#transport-address ipv4 10.143.73.1 0	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address
PE1(config-router)#targeted-peer ipv4 10.143.73.3	Configure targeted peer.
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

PE1: Interface Configuration Network Side

(config)#interface xe3	Enter the Interface mode for xe3
(config-if)#ip address 10.255.128.2/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

Note: For RSVP Configuration refer [RSVP-TE Configuration](#).

PE1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.1	Router-ID configurations
(config-router)#network 10.143.73.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.2/31 area 0.0.0.0	Advertise xe3 network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

PE1: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.3 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.3 update-source lo	Source of routing updates as loopback
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit candidate configuration to be running configuration

PE1: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.1:2	Configuring Route-Distinguisher value 10.143.73.1:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit candidate configuration to be running configuration

PE1: EVPN and VRF Mapping

(config)#evpn mpls id 2 xconnect target-mpls-id 252	Configure the EVPN-VPWS identifier with source identifier 2 and target identifier 252
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration

(config)#interface xe6	Enter the Interface mode for xe6.
(config-if)#description access-side-int	Giving Interface Description
(config-if)#interface xe6.2 switchport	Creating L2 sub interface of physical interface xe6

(config-if)#encapsulation dot1q 2	Setting Encapsulation to dot1q with VLAN ID 2 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 2	Map vpn-id 252 to interface xe2.2 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#commit	Commit candidate configuration to be running configuration

PE1: CFM Configuration

(config)#hardware-profile filter cfm-domain-name-str enable	Configure cfm-domain-name-str profile to enable cfm
(config)#ethernet cfm domain-type character-string domain-name MD-01 level 2 mip-creation none	Create CFM domain for Evpn ELine with type as character string and set mip creation to none
(config-ether-cfm-mpls-md)#service ma-type string ma-name S1	Create ma type with string and set mip creation to none
(config-ether-cfm-mpls-ma)# evpn 2	Configure evpn <Evpn-id>
(config-ether-cfm-mpls-ma)#ethernet cfm mep up mpid 8191 active true evpn 2	Create up-mep for local evpn id 2
(config-ether-cfm-mpls-ma-mep)#cc multicast state enable	Enable cc multicast
(config-ether-cfm-mpls-ma-mep)#exit-ether-ma-mep-mode	Exit Ethernet ma-mep-mode
(config-ether-cfm-mpls-ma)#mep crosscheck mpid 8000	Configure cross check to remote mep for vlan 2
(config-ether-cfm-mpls-ma)#cc interval 2	Enable cc interval with value 2 i.e 10 milliseconds
(config-ether-cfm-mpls-ma)#exit-ether-ma-mode	Exit ethernetnet ma mode
(config-ether-cfm-mpls-md)#exit	Exit Ethernet cfm mode
(config)#exit	Exit from config mode
(config)#commit	Commit candidate configuration to be running configuration

P: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.2/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

P: Global LDP

(config)#router ldp	Enter the Router LDP mode.
PE1(config-router)#router-id 10.143.73.2	Set the router ID to IP address 10.143.73.2

PE1 (config-router) #transport-address ipv4 10.143.73.2 0	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router) #exit	Exit from router target peer and LDP mode
(config) #commit	Commit candidate configuration to be running configuration

P: Interface Configuration

(config) #interface xe3	Enter the Interface mode for xe3
(config-if) #ip address 10.255.128.3/31	Configure IP address on the interface.
(config-if) #enable-ldp ipv4	Enable LDP on the physical interface
(config-if) #label-switching	Enable label switching on the interface.
(config-if) #exit	Exit interface mode
(config) #interface xe5	Enter the Interface mode for xe5
(config-if) #ip address 10.255.128.22/31	Configure IP address on the interface.
(config-if) #enable-ldp ipv4	Enable LDP on the physical interface
(config-if) #label-switching	Enable label switching on the interface.
(config-if) #exit	Exit interface mode
(config) #commit	Commit candidate configuration to be running configuration

P: OSPF Configuration

(config) #router ospf 100	Enter the Router OSPF mode.
(config-router) #ospf router-id 10.143.73.2	Setting the Router ID as Loopback IP
(config-router) #network 10.143.73.2/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router) #network 10.255.128.22/31 area 0.0.0.0	Advertise xe5 network address in OSPF
(config-router) #network 10.255.128.3/31 area 0.0.0.0	Advertise xe3 network address in OSPF.
(config-router) #exit	Exit Router OSPF mode and return to Configure mode.
(config) #commit	Commit candidate configuration to be running configuration

PE2: Loopback Interface

#configure terminal	Enter configuration mode.
(config) #interface lo	Enter the Interface mode for the loopback interface.
(config-if) #ip address 10.143.73.3/32 secondary	Configure IP address on loopback interface.
(config-if) #exit	Exit interface mode
(config) #commit	Commit candidate configuration to be running configuration

PE2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
PE1(config-router)#router-id 10.143.73.3	Set the router ID to IP address 10.143.73.3
PE1(config-router)#transport-address ipv4 10.143.73.3 0	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
PE1(config-router)#targeted-peer ipv4 10.143.73.1	Configure targeted peer.
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

PE2: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature.
(config)#evpn mpls vtep-ip-global 10.143.73.3	Configuring VTEP global IP to loopback IP
(config)#commit	Commit candidate configuration to be running configuration

PE2: Interface Configuration Network Side

(config)#interface xe5	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.23/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

PE2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.3	Router-ID configurations
(config-router)#network 10.143.73.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.23/31 area 0.0.0.0	Advertise xe5 network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

PE2: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.1 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit candidate configuration to be running configuration

PE2: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.3:2	Configuring Route-Distinguisher value 10.143.73.3:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit candidate configuration to be running configuration

PE2: EVPN and VRF Mapping

(config)#evpn mpls id 252 xconnect target-mpls-id 2	Configure the EVPN-ELINE identifier with source identifier 252 and target identifier 2
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-ELINE identifier
(config-evpn-mpls)#commit	Commit candidate configuration to be running configuration
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration:

(config)#interface xe2	Enter the Interface mode for xe2.
(config-if)#description access-side-int	Giving Interface Description
(config-if)#interface xe2.2 switchport	Creating L2 sub interface of physical interface xe2
(config-if)#encapsulation dot1q 2	Setting Encapsulation to dot1q with VLAN ID 2 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 252	Map vpn-id 252 to interface xe2.2 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#commit	Commit candidate configuration to be running configuration

PE2: CFM Configuration

(config)#hardware-profile filter cfm-domain-name-str enable	Configure cfm-domain-name-str profile to enable cfm
(config)#ethernet cfm domain-type character-string domain-name MD-01 level 2 mip-creation none	Create CFM domain for Evpn ELine with type as character string and set mip creation to none
(config-ether-cfm-mpls-md)#service ma-type string ma-name S1	Create ma type with string and set mip creation to none
(config-ether-cfm-mpls-ma)# evpn 252	Configure evpn <Evpn-id>
(config-ether-cfm-mpls-ma)#ethernet cfm mep up mpid 8000 active true evpn 252	Create up-mep for local evpn id 252
(config-ether-cfm-mpls-ma-mep)#cc multicast state enable	Enable cc multicast
(config-ether-cfm-mpls-ma-mep)#exit-ether-ma-mep-mode	Exit Ethernet ma-mep-mode
(config-ether-cfm-mpls-ma)#mep crosscheck mpid 8191	Configure cross check to remote mep for vlan 2
(config-ether-cfm-mpls-ma)#cc interval 2	Enable cc interval with value 2 i.e 10 milliseconds
(config-ether-cfm-mpls-ma)#exit-ether-ma-mode	Exit ethernet ma mode
(config-ether-cfm-mpls)#exit	Exit Ethernet cfm mode
(config)#exit	Exit from config mode
(config)#commit	Commit candidate configuration to be running configuration

Validation

PE1

```
PE1#show evpn mpls xconnect id 2
```

```
EVPN-MPLS Xconnect Info
```

```
=====
```

```
AC-AC: Local-Cross-connect
```

```
AC-NW: Cross-connect to Network
```

```
AC-UP: Access-port is up
```

```
AC-DN: Access-port is down
```

```
NW-UP: Network is up
```

```
NW-DN: Network is down
```

```
NW-SET: Network and AC both are up
```

Local			Remote		Connection-Details				
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status
2	----	1500	252	xe6.2	--- Single Homed Port ---	10.143.73.3	1500	AC-NW	NW-SET

```
Total number of entries are 1
```

```
PE1#show ethernet cfm errors domain MD-01
```

Domain Name	Level	MEPID	Defects
MD-01	2	8191

```
1. defRDICCM      2. defMACstatus  3. defRemoteCCM
4. defErrorCCM    5. defXconCCM
```

```
PE1#show ethernet cfm ma status domain MD-01 ma-name S1
MA NAME                               STATUS
-----
S1                                     Active

PE1#show ethernet cfm maintenance-points local mep domain MD-01 ma-name S1
MPID Dir Lvl CC-Stat HW-Status  CC-Intvl MAC-Address  Def Port  MD Name
-----
8191 Up  2   Enable  Installed  10 ms    e8c5.7a78.7124 F   xe6.2 MD-01

PE1#show ethernet cfm maintenance-points remote domain MD-01 ma-name S1
MEPID    RMEPID    LEVEL    Rx CCM    RDI    PEER-MAC    TYPE
-----
8191     8000     2        Yes     False  b86a.97cb.6c6e Configured

PE1#show ethernet cfm maintenance-points remote mpid 8191 domain MD-01 ma-name S1
MEPID    RMEPID    LEVEL    Rx CCM    RDI    PEER-MAC    TYPE
-----
8191     8000     2        Yes     False  b86a.97cb.6c6e Configured

PE1#ping ethernet mac b86a.97cb.6c6e unicast source 8191 domain MD-01 ma-name S1
success rate is 100 (5/5)

PE1#traceroute ethernet b86a.97cb.6c6e mepid 8191 domain MD-01 ma-name S1
MP Mac      Hops  Relay-action      Ingress/Egress  Ingress/Egress action
b86a.97cb.6c6e  1    RlyHit           Ingress         IngOK

PE1#show ethernet cfm statistics mep 8191 domain MD-01

CFM Statistics for MEP 8191 of MD MD-01
=====
Continuity Check Messages
  CCM Sent           : CCM Stats Profile Disabled
  CCM Received       : CCM Stats Profile Disabled

Loop Back Messages
  LBM Sent           : 5
  LBR Received(Valid) : 5
  LBR Received(Bad msdu) : 0
  LBR Received(Out-of-Seq) : 0

Link Trace Messages
  LTM Sent           : 1
  LTR Sent           : 0
  LTR Received(Valid) : 1
  LTR Received(unexpected) : 0
```

PE2

```
PE2#show evpn mpls xconnect id 252
EVPN-MPLS Xconnect Info
=====
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                               Remote      Connection-Details
=====
=====
VPN-ID      EVI-Name      MTU    VPN-ID      Source      Destination      PE-IP      MTU    Type    NW-Status
=====
252         ----          1500   2           xe2.2       --- Single Homed Port --- 10.143.73.1 1500   AC-NW   NW-SET

Total number of entries are 1

PE2#show ethernet cfm errors domain MD-01
```

Domain Name	Level	MEPID	Defects
MD-01	2	8000

```

1. defRDICCM      2. defMACstatus  3. defRemoteCCM
4. defErrorCCM    5. defXconCCM

```

```

PE3#show ethernet cfm ma status domain MD-01 ma-name S1
ma-name S1
MA NAME                STATUS
-----
S1                      Active

```

```

PE2#show ethernet cfm maintenance-points local mep domain MD-01 ma-name S1
MPID Dir Lvl CC-Stat HW-Status CC-Intvl MAC-Address Def Port MD Name
-----
8000 Up  2   Enable  Installed 10 ms    b86a.97cb.6c6e F   xe2.2 MD-01

```

```

PE3#show ethernet cfm maintenance-points remote domain MD-01 ma-name S1
MEPID RMEPID LEVEL Rx CCM RDI PEER-MAC TYPE
-----
8000   8191   2     Yes   False e8c5.7a78.7124 Configured

```

```

PE2#show ethernet cfm maintenance-points remote mpid 8000 domain MD-01 ma-name S1
MEPID RMEPID LEVEL Rx CCM RDI PEER-MAC TYPE
-----
8000   8191   2     Yes   False e8c5.7a78.7124 Configured

```

```

PE2#traceroute ethernet e8c5.7a78.7124 mepid 8000 domain MD-01 ma-name S1
MP Mac      Hops Relay-action      Ingress/Egress Ingress/Egress action
e8c5.7a78.7124 1    RlyHit          Ingress        IngOK

```

```

PE2#show ethernet cfm statistics mep 8000 domain MD-01 ma-name S1

```

```

CFM Statistics for MEP 8000 of MD MD-01
=====

```

Continuity Check Messages

```

CCM Sent           : CCM Stats Profile Disabled
CCM Received       : CCM Stats Profile Disabled

```

Loop Back Messages

```

LBM Sent           : 5
LBR Received(Valid) : 5
LBR Received(Bad msdu) : 0
LBR Received(Out-of-Seq) : 0

```

Link Trace Messages

```

LTM Sent           : 1
LTR Sent           : 1
LTR Received(Valid) : 1
LTR Received(unexpected) : 0

```

CHAPTER 2 EVPN MPLS IRB Configuration

This chapter includes step-by-step configurations for EVPN MPLS IRB.

Overview

EVPN provides an extensible and flexible multihoming VPN solution over an MPLS/IP network for intra-subnet connectivity among Tenant Systems (TSs) and end devices that can be physical or virtual, where an IP subnet is represented by an EVPN instance (EVI) for a VLAN-based service or by an (EVI, VLAN) association for a VLAN-aware bundle service. However, there are scenarios for which there is a need for a dynamic and efficient inter-subnet connectivity among these Tenant Systems and end devices while maintaining the multihoming capabilities of EVPN. This document describes an Integrated Routing and Bridging (IRB) solution based on EVPN to address such requirements

Integrated Routing and Bridging combines switching of tenant data with routing into different VNID of the same tenant. This is accomplished by having a unique per-tenant layer 3 IP-VRF across all PEs hosting tenant systems for that tenant and the layer-2 MAC VRFs (mapping to one or more bridged domains (VNIDS)) belonging to that tenant on different PEs being mapped to the common IP-VRF through logical interfaces called IRB interfaces. The MAC-VRF tables are used for switching intra-subnet communication whereas the IP-VRF tables are used for routing inter-subnet traffic.

IRB has two modes of working.

- Asymmetric IRB (Anycast and Centralized)
- Symmetric IRB (Distributed)

Asymmetric IRB

In asymmetric IRB, the lookup operation is asymmetric and the ingress PE performs three lookups, whereas the egress PE performs a single lookup -- i.e., the ingress PE performs a MAC lookup, followed by an IP lookup, followed by a MAC lookup again. The egress PE performs just a single MAC lookup as depicted in following figure:

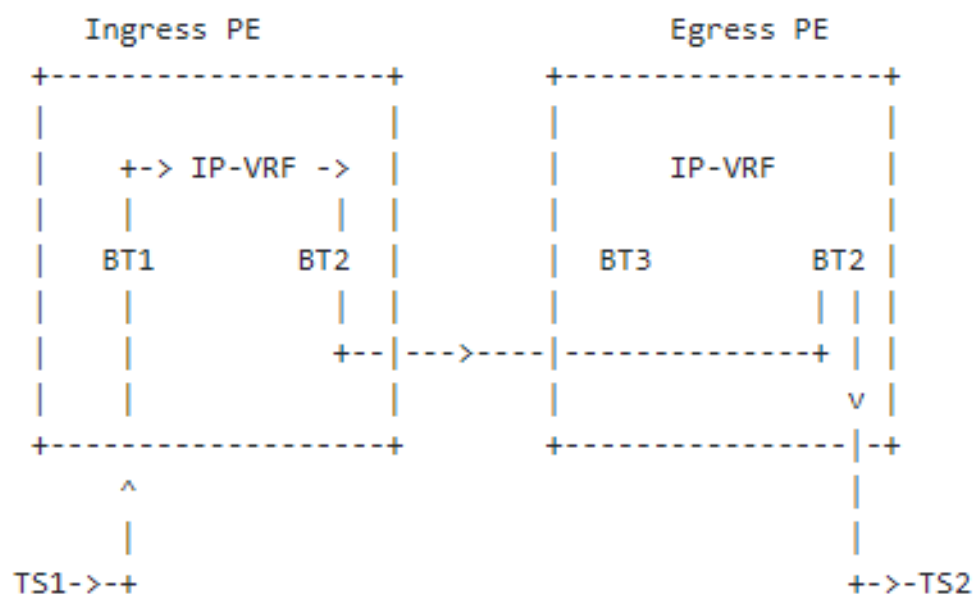


Figure 2-1: Asymmetric IRB

In other words, each PE participating in asymmetric IRB MUST maintain ARP entries for remote hosts (hosts connected

to other PEs) as well as maintain MAC-VRFs/BTs and IRB interfaces for ALL subnets in an IP-VRF, including subnets that may not be locally attached.

Symmetric IRB

In symmetric IRB, as its name implies, the lookup operation is symmetric at both the ingress and egress PEs -- i.e., both ingress and egress PEs perform lookups on both MAC and IP addresses. The ingress PE performs a MAC lookup followed by an IP lookup, and the egress PE performs an IP lookup followed by a MAC lookup, as depicted in the following figure:

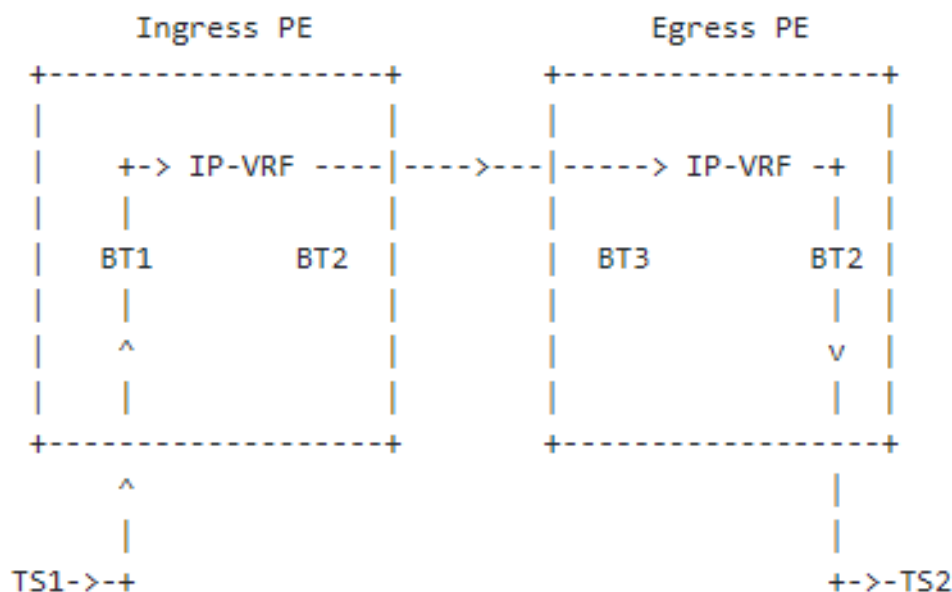


Figure 2-2: Symmetric IRB

Therefore, in symmetric IRB, there is no need for the ingress PE to maintain ARP entries for the association of the destination TS2's IP and MAC addresses in its ARP table. Each PE participating in symmetric IRB only maintains ARP entries for locally connected hosts and MAC-VRFs/BTs for only locally configured subnets.

Route Types

These EVPN route types are supported:

- Route Type 1: Ethernet Auto-Discovery (AD) Route

The Ethernet (AD) routes are advertised on per EVI and per ESI basis. These routes are sent per ES. They carry the list of EVIs that belong to the ES.

This route is advertised when multihomed CEs already exist.

- Route Type 2: MAC/IP Advertisement Route

The host's IP and MAC addresses are advertised to the peers within NLRI. The control plane learning of MAC addresses reduces unknown unicast flooding.

- Route Type 3: Inclusive Multicast Ethernet Tag Route

This route establishes the connection for broadcast, unknown unicast, and multicast (BUM) traffic from a source PE to a remote PE.

This route is advertised on per VLAN and per ESI basis.

- Route Type 4: Ethernet Segment Route

Ethernet segment routes enable to connect a CE device to two or PE devices.

Ethernet segment routes enable the discovery of connected PE devices that are connected to the same Ethernet segment.

- Route Type 5: IP prefix Route

An IP prefix route provides encoding for inter-subnet forwarding. In the control plane, EVPN Type 5 routes are used to advertise IP prefixes for inter-subnet connectivity across data centers.

In EVPN-VPWS the auto-discovery of peer PE nodes is done with the pair of Ethernet A-D routes. Inclusive Multicast route does not have participation on auto-discovery unlike ELAN-EVPN VPLS. Since there is no MAC-advertisement, MAC-IP route is not applicable.

Note:

1. RD value should be unique for multihoming nodes.
2. ANYCAST gateway MAC is mandatory on multihoming nodes.
3. "rewrite pop" is mandatory on access interface.
4. arp-nd refresh timer needs to be configured to avoid ARP table getting clear after ARP timeout.

EVPN MPLS IRB Symmetric Distributed mode

Topology

[Figure 2-3](#) depicts the EVPN MPLS IRB with LDP as underlay MPLS path.

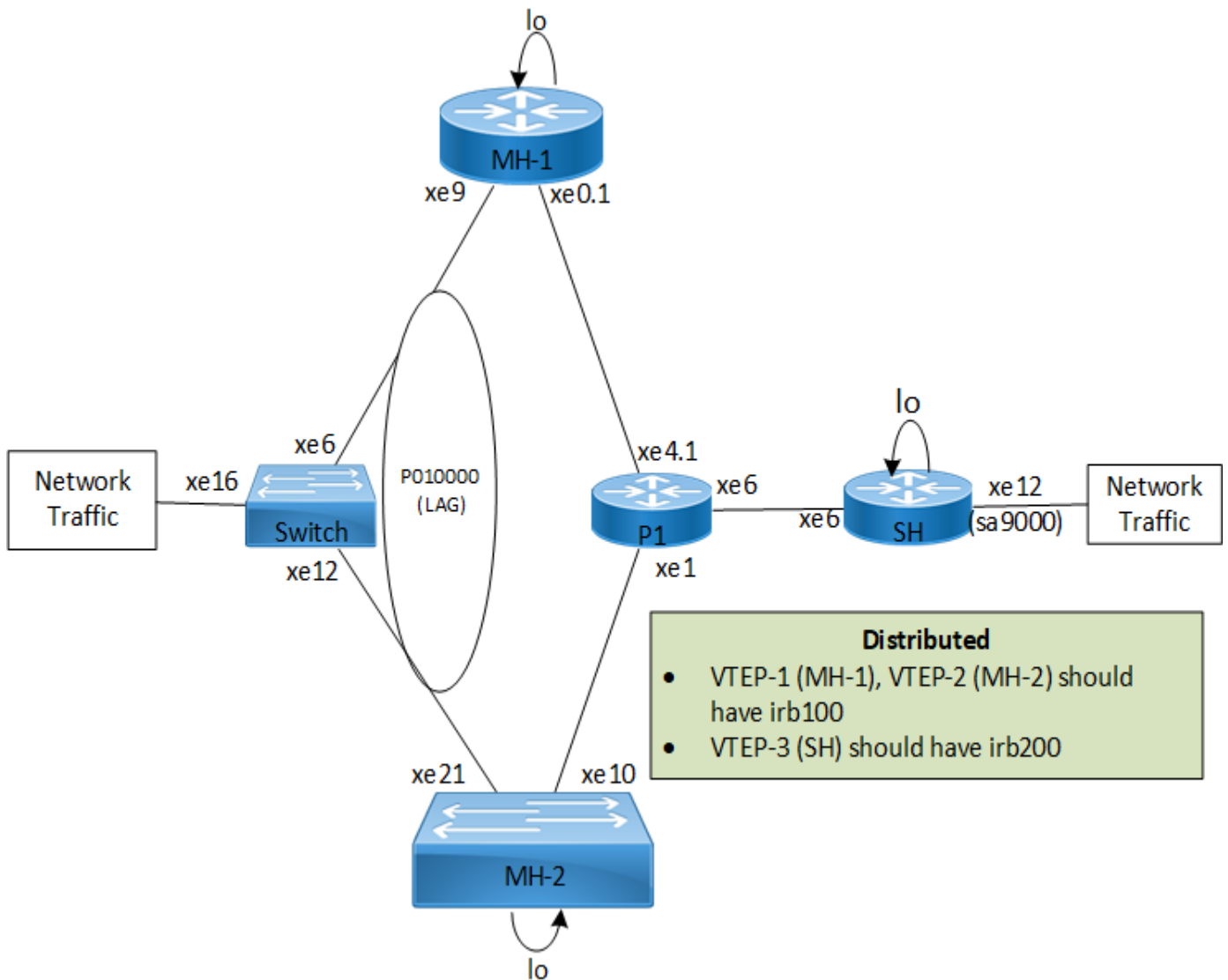


Figure 2-3: EVPN MPLS IRB Distributed configuration

Configurations

SH1

Enable EVPN MPLS and IRB

#configure terminal	Enter configuration mode.
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally

Loopback Interface

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 5.5.5.5/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF

(config)#mac vrf green	Create MAC VRF green.
(config-vrf)# rd 5.5.5.5:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF

(config)#ip vrf evpn	Configure IP VRF evpn.
(config-vrf)# rd 30:200	Configure route distinguisher
(config-vrf)# route-target both 100:200	Configure route target
(config-vrf)# l3vni 20000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configuring IRB interface

(config)#interface irb200	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding evpn	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 70.70.1.1/24	Assign IP address
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID

(config)#evpn mpls vtep-ip-global 5.5.5.5	Configure VTEP global IP
(config)#evpn mpls id 200	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachability-protocol evpn-bgp green	Map the MAC VRF green
(config-evpn-mpls)# evpn irb irb200	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 5.5.5.5	Enter LDP router-id
(config-router)# transport-address ipv4 5.5.5.5	Configure LDP transport address

(config-router)# targeted-peer ipv4 2.2.2.2	Configure LDP target peer address (MH-1)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 3.3.3.3	Configure LDP target peer address (MH-2)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side

(config-if)#interface xe6	Enter interface mode
(config-if)# description connected to P1	Configure interface description
(config-if)# ip address 30.30.30.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#ospf router-id 5.5.5.5	Configure OSPF router id
(config-router)# network 5.5.5.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit OSPF mode

BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring MH-1 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 3.3.3.3 remote-as 65010	Configuring MH-2 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 3.3.3.3 update-source lo	Source of routing updates as loopback
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 2.2.2.2 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 3.3.3.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode

(config-router)# address-family ipv4 vrf evpn	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration

(config-if)#interface sa9000	Creating Static LAG interface
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)#exit	Exiting out of interface mode
(config-if)#interface sa9000.200 switchport	Creating Static LAG L2 sub interface of physical interface xe12
(config-if)# encapsulation dot1q 200	Setting Encapsulation to dot1q with VLAN ID 200
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)#map vpn-id 200	Map VPN-ID 200
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config-if)#interface xe12	Enter the Interface mode
(config-if)# static-channel-group 9000	Map the physical interface xe12 as static LAG member
(config-if)#exit	Exit interface mode

P1

Loopback Interface:

#configure terminal	Enter configuration mode.
(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 4.4.4.4/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)# router-id 4.4.4.4	Configure router id
(config-router)# transport-address ipv4 4.4.4.4	Configure transport address
(config-router)#exit	Exit from LDP mode
(config-router)#exit	Exit from LDP mode

Interface Configuration

(config-if)#interface xe4	Enter the Interface mode for xe4.
(config-if)# mtu 9216	Configure MTU.
(config-if)#exit	Enable LDP on the physical interface

(config)#interface xe4.1	Create sub-interface xe4.1.
(config-if)# description connected-to-MH-1	Configure Interface description
(config-if)# ip address 10.10.10.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# encapsulation dot1q 20	Configure encapsulation as dotq
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter into Interface mode
(config-if)# description connected to MH-2	Configure Interface description
(config-if)# ip address 20.20.20.2/24	Configure IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe6	Enter into Interface mode
(config-if)# description connected to SH	Configure Interface description
(config-if)# ip address 30.30.30.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 4.4.4.4	Setting the Router ID as Loopback IP
(config-router)# network 4.4.4.4/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.10.10.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)# network 20.20.20.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

MH-1**Enable EVPN MPLS and IRB**

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mpls-mh enable	Configure hardware profile to enable EVPN MPLS multihoming in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF

(config-vrf)#mac vrf green	Create MAC VRF green.
(config-vrf)# rd 2.2.2.2:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto-rt (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF

(config)#ip vrf evpn	Configure IP VRF evpn.
(config-vrf)# rd 10:200	Configure route distinguisher
(config-vrf)# route-target both 100:200	Configure route target
(config-vrf)# l3vni 20000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configure Anycast Gateway MAC

:

(config)#evpn irb-forwarding anycast-gateway- mac 0011.2233.4455	Configure anycast gateway MAC globally
(config)#interface irb100	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding evpn	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 80.80.1.1/24 anycast	Assign IP address
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID

(config)#evpn mpls vtep-ip-global 2.2.2.2	Configure VTEP global IP
(config)#evpn mpls id 100	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp green	Map the MAC VRF green
(config-evpn-mpls)# evpn irb irb100	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP

(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 2.2.2.2	Enter LDP router-id
(config-router)# transport-address ipv4 2.2.2.2	Configure LDP transport address
(config-router)# targeted-peer ipv4 5.5.5.5	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side

(config-if)#interface xe0	Enter the Interface mode for xe0.
(config-if)# mtu 9216	Configure MTU.
(config-if)#exit	Exit from interface xe0
(config)#interface xe0.1	Create subinterface in xe10
(config-if)# encapsulation dot1q 20	Configure encapsulation as dotq
(config-if)# ip address 10.10.10.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4

OSPF Configuration

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 2.2.2.2	Router-ID configurations
(config-router)# network 2.2.2.2/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.10.10.0/24 area 0.0.0.0	Advertise network address in OSPF.

BGP Configuration

(config-router)#router bgp 65010	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 3.3.3.3 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 3.3.3.3 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 5.5.5.5 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 3.3.3.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 5.5.5.5 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf evpn	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration

(config)#interface xe9	Enter configuration mode
(config-if)# mtu 9216	Configure MTU
(config-if)# channel-group 10000 mode active	Configure physical interface xe9 as LAG member po10000
(config-if)#exit	Exit from interface xe9
(config)#interface po10000	Create LAG interface po10000
(config-if)# mtu 9216	Configure MTU
(config-if)# description connected to Switch	Configure Interface description
(config-if)# evpn multi-homed system-mac 0000.1111.aaaa	Configure system MAC for multi homing
(config)#interface po10000.100 switchport	Creating L2 sub interface of physical interface xe9
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 100	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode

MH-2**Enable EVPN MPLS and IRB**

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mplsmh enable	Configure hardware profile to enable EVPN MPLS multihoming in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface

(config-if)#interface lo	Enter the Interface mode for the loopback interface
(config-if)# ip address 3.3.3.3/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF

(config-vrf)#mac vrf green	Create MAC VRF green.
(config-vrf)# rd 3.3.3.3:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto-rt (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF

(config)#ip vrf evpn	Configure IP VRF evpn.
(config-vrf)# rd 20:200	Configure route distinguisher
(config-vrf)# route-target both 100:200	Configure route target
(config-vrf)# l3vni 20000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configure Anycast Gateway MAC

(config)#evpn irb-forwarding anycastgateway-mac 0011.2233.4455	Configure anycast gateway MAC globally
--	--

Configuring IRB interface

(config)#interface irb100	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding evpn	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 80.80.1.1/24 anycast	Assign IP address

(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID

(config)#evpn mpls vtep-ip-global 3.3.3.3	Configure VTEP global IP
(config)#evpn mpls id 100	Create EVPN MPLS ID
(config-evpn-mpls)# host- reachabilityprotocol evpn-bgp green	Map the MAC VRF green
(config-evpn-mpls)# evpn irb irb100	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)# transport-address ipv4 3.3.3.3	Configure LDP transport address
(config-router)# targeted-peer ipv4 5.5.5.5	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side

(config-if)#interface xe10	Enter the configuration mode.
(config-if)# description connected to P1	Configure Interface description
(config-if)# ip address 20.20.20.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 3.3.3.3	Router-ID configurations
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 20.20.20.0/24 area 0.0.0.0	Advertise network address in OSPF.

BGP Configuration

(config-router)#router bgp 65010	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 5.5.5.5 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 2.2.2.2 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 5.5.5.5 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf evpn	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration

(config)#interface xe21	Enter configuration mode
(config-if)# mtu 9216	Configure MTU
(config-if)# channel-group 10000 mode active	Configure physical interface xe21 as LAG member po10000
(config-if)#exit	Exit from interface xe21
(config)#interface po10000	Create LAG interface po10000
(config-if)# mtu 9216	Configure MTU
(config-if)# description connected to Switch	Configure Interface description
(config-if)# evpn multi-homed system-mac 0000.1111.aaaa	Configure system MAC for multi homing
(config)#interface po10000.100 switchport	Creating L2 sub interface of physical interface xe21
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 100	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode

Validation

Note: Remote entries cannot be fetched from through MAC table/ARP cache/ND cache. However they can be fetched from the BGP table.

MH-1

```
MH-1#sh evpn mpls
EVPN-MPLS Information
=====
```

```
Codes: NW - Network Port
       AC - Access Port
       (u) - Untagged
```

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF
Status	Src-Addr		Dst-Addr				
100	----	L2	NW	----	----	----	-
---	2.2.2.2		3.3.3.3				
100	----	L2	NW	----	----	----	-
---	2.2.2.2		5.5.5.5				
100	----	--	AC	po10000.100	00:00:00:11:11:aa:aa:00:00:00	----	DF
----	----	----					
200	----	L2	NW	----	----	----	-
---	2.2.2.2		3.3.3.3				
200	----	L2	NW	----	----	----	-
---	2.2.2.2		5.5.5.5				
200	----	--	AC	po10000.200	00:00:00:11:11:aa:aa:00:00:00	----	DF
----	----	----					
10000	----	L3	NW	----	----	----	-
---	2.2.2.2		3.3.3.3				
10000	----	L3	NW	----	----	----	-
---	2.2.2.2		5.5.5.5				

Total number of entries are 8

```
MH-1#
```

```
MH-1#sh evpn mpls tunnel
```

```
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	evpn-id
2.2.2.2	3.3.3.3	Installed	01:16:34	01:16:34	200
2.2.2.2	3.3.3.3	Installed	01:16:34	01:16:34	100
2.2.2.2	3.3.3.3	Installed	01:23:48	01:23:48	10000
2.2.2.2	5.5.5.5	Installed	01:14:59	01:14:59	200
2.2.2.2	5.5.5.5	Installed	01:14:59	01:14:59	100
2.2.2.2	5.5.5.5	Installed	01:23:48	01:23:48	10000

Total number of entries are 6

```
MH-1#
```

```
MH-1#sh evpn mpls mac-table
```

```
=====
=====
```

EVPN MPLS MAC Entries

VNID Status	Interface MAC move	VlanId Access	In-VlanId Port	Mac-Addr Desc	VTEP-Ip/ESI	Type
100	irb100	----	----	0011.2233.4455	2.2.2.2	
Static Local	-----	0	-----			
100	-----	-----	----	9819.2c86.3e01	5.5.5.5	
Static Remote	-----	0	-----			
100	po10000.100	----	----	0010.9400.0001	00:00:00:11:11:aa:aa:00:00:00	
Dynamic Local	-----	0	-----			
100	-----	-----	----	0010.9400.0004	5.5.5.5	
Dynamic Remote	-----	0	-----			
200	irb200	----	----	0011.2233.4455	2.2.2.2	
Static Local	-----	0	-----			
200	-----	-----	----	9819.2c86.3e01	5.5.5.5	
Static Remote	-----	0	-----			
200	po10000.200	----	----	0010.9400.0002	00:00:00:11:11:aa:aa:00:00:00	
Dynamic Local	-----	0	-----			
200	-----	-----	----	0010.9400.0005	5.5.5.5	
Dynamic Remote	-----	0	-----			

Total number of entries are : 8

MH-1#

MH-1#sh evpn mpls arp-cache

MPLS-EVPN ARP-CACHE Information

ARP Timeout : 300 sec Random-Jitter-Max : 200

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
100	80.80.1.1	0011.2233.4455	Static Local	----	
100	80.80.1.2	0010.9400.0001	Dynamic Local	244	2
100	80.80.1.3	9819.2c86.3e01	Static Remote	----	
100	80.80.1.4	0010.9400.0004	Dynamic Remote	----	
200	90.90.1.1	0011.2233.4455	Static Local	----	
200	90.90.1.2	0010.9400.0002	Dynamic Local	----	
200	90.90.1.3	9819.2c86.3e01	Static Remote	----	
200	90.90.1.4	0010.9400.0005	Dynamic Remote	----	

Total number of entries are 8

MH-1#

MH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:100] VRF[red]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	3.3.3.3	MPLS

RD[2.2.2.2:200] VRF[blue]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
-----	---------	------------	------------	-------

```

00:00:00:11:11:aa:aa:00:00:00 4294967295 19 3.3.3.3 MPLS

RD[2.2.2.2:64512] VRF[evpn-gvrf-1]:
ESI Eth-Tag VNID/LABEL Nexthop IP Encap
00:00:00:11:11:aa:aa:00:00:00 4294967295 19 2.2.2.2 MPLS

RD[3.3.3.3:64512]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap
00:00:00:11:11:aa:aa:00:00:00 4294967295 19 3.3.3.3 MPLS
MH-1#
MH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100] VRF[red]:
ESI Eth-Tag VNID/LABEL Nexthop IP Encap
00:00:00:11:11:aa:aa:00:00:00 100 17 3.3.3.3 MPLS
00:00:00:11:11:aa:aa:00:00:00 100 17 2.2.2.2 MPLS

RD[2.2.2.2:200] VRF[blue]:
ESI Eth-Tag VNID/LABEL Nexthop IP Encap
00:00:00:11:11:aa:aa:00:00:00 200 18 3.3.3.3 MPLS
00:00:00:11:11:aa:aa:00:00:00 200 18 2.2.2.2 MPLS

RD[3.3.3.3:100]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap
00:00:00:11:11:aa:aa:00:00:00 100 17 3.3.3.3 MPLS

RD[3.3.3.3:200]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap
00:00:00:11:11:aa:aa:00:00:00 200 18 3.3.3.3 MPLS
MH-1#
MH-1#sh evpn mpls label esi
S - Self
R - Remote
ESI PE-IP-ADDRESS ESI-LABEL
=====
00:00:00:11:11:aa:aa:00:00:00 2.2.2.2(S) 19
00:00:00:11:11:aa:aa:00:00:00 3.3.3.3(R) 19
MH-1#
MH-1#sh evpn mpls label alias
S - Self
R - Remote
ESI PE-IP-ADDRESS TENANT ALIAS-LABEL
=====
=====
00:00:00:11:11:aa:aa:00:00:00 2.2.2.2(S) 100 17
00:00:00:11:11:aa:aa:00:00:00 2.2.2.2(S) 200 18
00:00:00:11:11:aa:aa:00:00:00 3.3.3.3(R) 100 17
00:00:00:11:11:aa:aa:00:00:00 3.3.3.3(R) 200 18
MH-1#
MH-1#sh bgp l2vpn evpn
BGP table version is 10, local router ID is 2.2.2.2

```

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]

1 - Ethernet Auto-discovery Route

2 - MAC/IP Route

3 - Inclusive Multicast Route

4 - Ethernet Segment Route

5 - Prefix Route

Network Encap	Next Hop	Metric	LocPrf	Weight	Path	Peer
RD[20:200]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	3.3.3.3	0	100	0	?	3.3.3.3 MPLS
*>i [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]	3.3.3.3	0	100	0	?	3.3.3.3 MPLS
RD[30:200]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	5.5.5.5	0	100	0	?	5.5.5.5 MPLS
*>i [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]	5.5.5.5	0	100	0	?	5.5.5.5 MPLS
RD[2.2.2.2:100] VRF[red]:						
* i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]	3.3.3.3	0	100	0	i	3.3.3.3 MPLS
*>	2.2.2.2	0	100	32768	i	----- MPLS
* i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]	3.3.3.3	0	100	0	i	3.3.3.3 MPLS
*>	[2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]	0	100	32768	i	----- MPLS
*>	[2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]	0	100	32768	i	----- MPLS
* i [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]	5.5.5.5	0	100	0	i	5.5.5.5 MPLS
* i [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]	5.5.5.5	0	100	0	i	5.5.5.5 MPLS
* i [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]	3.3.3.3	0	100	0	i	3.3.3.3 MPLS
*>	2.2.2.2	0	100	32768	i	----- MPLS
* i [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]	5.5.5.5	0	100	0	i	5.5.5.5 MPLS
*>	[3]:[100]:[32,2.2.2.2]	0	100	32768	i	----- MPLS
* i [3]:[100]:[32,3.3.3.3]	3.3.3.3	0	100	0	i	3.3.3.3 MPLS
* i [3]:[100]:[32,5.5.5.5]						


```

5.5.5.5          0          100          0    i  5.5.5.5          MPLS

RD[2.2.2.2:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>    2.2.2.2          0          100          32768 i  -----          MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>    [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
      2.2.2.2          0          100          32768 i  -----          MPLS
*>    [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
      2.2.2.2          0          100          32768 i  -----          MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>    2.2.2.2          0          100          32768 i  -----          MPLS
* i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>    [3]:[200]:[32,2.2.2.2]
      2.2.2.2          0          100          32768 i  -----          MPLS
* i  [3]:[200]:[32,3.3.3.3]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [3]:[200]:[32,5.5.5.5]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS

RD[2.2.2.2:64512] VRF[evpn-gvrf-1]:
*>    [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
      2.2.2.2          0          100          32768 i  -----          MPLS
*>    [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
      2.2.2.2          0          100          32768 i  -----          MPLS
* i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [3]:[100]:[32,3.3.3.3]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [3]:[200]:[32,3.3.3.3]

```

```

3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[5.5.5.5:100]
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [3]:[100]:[32,5.5.5.5]
5.5.5.5          0          100          0    i  5.5.5.5          MPLS

RD[5.5.5.5:200]
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [3]:[200]:[32,5.5.5.5]
5.5.5.5          0          100          0    i  5.5.5.5          MPLS

Total number of prefixes 45
MH-1#
MH-1#sh bgp l2vpn evpn prefix-route

RD[20:200]
ESI      Eth-Tag Prefix-Length IP-Address  GW-IPAddress  L3VNID/LABEL
Nexthop  Encap      Router-Mac
0         0         24         80.80.1.0   0.0.0.0       16
3.3.3.3   MPLS       e8c5:7ad2:5d98
0         0         24         90.90.1.0   0.0.0.0       16
3.3.3.3   MPLS       e8c5:7ad2:5d98

RD[30:200]
ESI      Eth-Tag Prefix-Length IP-Address  GW-IPAddress  L3VNID/LABEL
Nexthop  Encap      Router-Mac
0         0         24         80.80.1.0   0.0.0.0       16
5.5.5.5   MPLS       9819:2c86:3e01
0         0         24         90.90.1.0   0.0.0.0       16
5.5.5.5   MPLS       9819:2c86:3e01
MH-1#
MH-1#sh bgp l2vpn evpn summary
BGP router identifier 2.2.2.2, local AS number 65010
BGP table version is 10
1 BGP AS-PATH entries

```

0 BGP community entries

Neighbor PfxRcd	AD	MACIP	V MCAST	AS	MsgRcv ESI	MsgSen PREFIX-ROUTE	TblVer	InQ	OutQ	Up/Down	State/
3.3.3.3			4	65010	205	203	9	0	0	01:17:25	
10	3	2	2	1	2						
5.5.5.5			4	65010	187	197	9	0	0	01:15:01	
10	0	6	2	0	2						

Total number of neighbors 2

Total number of Established sessions 2

MH-1#

MH-1#sh ip bgp vrf evpn_anycast

BGP table version is 1, local router ID is 90.90.1.1

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 80.80.1.0/24	0.0.0.0	0	100	32768	?
* i	5.5.5.5	0	100	0	?
* i	3.3.3.3	0	100	0	?
*> 90.90.1.0/24	0.0.0.0	0	100	32768	?
* i	5.5.5.5	0	100	0	?
* i	3.3.3.3	0	100	0	?

Total number of prefixes 2

MH-1#

MH-1#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

(m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	3.3.3.3/32	1	3				
			2	-	Yes	LSP_DEFAULT	25600
xe0.1	No	10.10.10.2					
L>	4.4.4.4/32	2	6				
			5	-	Yes	LSP_DEFAULT	3
xe0.1	No	10.10.10.2					
L>	5.5.5.5/32	5	8				
			7	-	Yes	LSP_DEFAULT	25603
xe0.1	No	10.10.10.2					
L>	20.20.20.0/24	3	6				
			5	-	Yes	LSP_DEFAULT	3
xe0.1	No	10.10.10.2					
L>	30.30.30.0/24	4	6				

```
xe0.1      No      10.10.10.2      5      -      Yes      LSP_DEFAULT  3
```

```
MH-1#
```

```
MH-1#sh ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
5.5.5.5	xe0.1	Passive	OPERATIONAL	30	01:14:50
4.4.4.4	xe0.1	Passive	OPERATIONAL	30	01:16:35

```
MH-1#
```

```
MH-1#sh ip ospf neighbor
```

```
Total number of full neighbors: 1
```

```
OSPF process 100 VRF(default):
```

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
4.4.4.4	1	Full/DR	00:00:39	10.10.10.2	xe0.1	0

```
MH-1#
```

```
MH-1#sh nvo vxlan l3vni-map
```

L3VNI	L2VNI	IRB-interface
10000	100	irb100
10000	200	irb200

```
MH-1#
```

MH-2

```
MH-2#sh evpn mpls
```

```
EVPN-MPLS Information
```

```
=====
```

```
Codes: NW - Network Port
       AC - Access Port
       (u) - Untagged
```

VPN-ID Status	EVI-Name Src-Addr	EVI-Type Type	EVI-Type Dst-Addr	Interface	ESI	VLAN	DF-
100	----	L2	NW	----	----	----	-
---	3.3.3.3		5.5.5.5				
100	----	L2	NW	----	----	----	-
---	3.3.3.3		2.2.2.2				
100	----	--	AC	po10000.100	00:00:00:11:11:aa:aa:00:00:00	----	
NON-DF	----		----				
200	----	L2	NW	----	----	----	-
---	3.3.3.3		5.5.5.5				
200	----	L2	NW	----	----	----	-
---	3.3.3.3		2.2.2.2				
200	----	--	AC	po10000.200	00:00:00:11:11:aa:aa:00:00:00	----	
NON-DF	----		----				
10000	----	L3	NW	----	----	----	-
---	3.3.3.3		5.5.5.5				
10000	----	L3	NW	----	----	----	-
---	3.3.3.3		2.2.2.2				

Total number of entries are 8

MH-2#

MH-2#sh evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
3.3.3.3	5.5.5.5	Installed	01:15:41	01:15:41	200
3.3.3.3	5.5.5.5	Installed	01:15:41	01:15:41	100
3.3.3.3	5.5.5.5	Installed	01:24:08	01:24:08	10000
3.3.3.3	2.2.2.2	Installed	01:17:15	01:17:15	200
3.3.3.3	2.2.2.2	Installed	01:17:15	01:17:15	100
3.3.3.3	2.2.2.2	Installed	01:24:08	01:24:08	10000

Total number of entries are 6

MH-2#

MH-2#sh evpn mpls mac-table

EVPN MPLS MAC Entries					
VNID	Interface	VlanId	In-VlanId	Mac-Addr	VTEP-Ip/ESI
Status	MAC move	AccessPort	Desc		Type
100	irb100	----	----	0011.2233.4455	3.3.3.3
Static Local	-----	0	-----		
100	----	----	----	9819.2c86.3e01	5.5.5.5
Static Remote	-----	0	-----		
100	----	----	----	0010.9400.0001	00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote	-----	0	-----		
100	----	----	----	0010.9400.0004	5.5.5.5
Dynamic Remote	-----	0	-----		
200	irb200	----	----	0011.2233.4455	3.3.3.3
Static Local	-----	0	-----		
200	----	----	----	9819.2c86.3e01	5.5.5.5
Static Remote	-----	0	-----		
200	----	----	----	0010.9400.0002	00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote	-----	0	-----		
200	----	----	----	0010.9400.0005	5.5.5.5
Dynamic Remote	-----	0	-----		

Total number of entries are : 8

MH-2#

MH-2#sh evpn mpls arp-cache

MPLS-EVPN ARP-CACHE Information

=====

ARP Timeout : 300 sec Random-Jitter-Max : 200

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
---------	---------	----------	------	---------	--------------

```

100      80.80.1.1      0011.2233.4455 Static Local  ----
100      80.80.1.2      0010.9400.0001 Dynamic Remote ----
100      80.80.1.3      9819.2c86.3e01 Static Remote  ----
100      80.80.1.4      0010.9400.0004 Dynamic Remote ----
200      90.90.1.1      0011.2233.4455 Static Local  ----
200      90.90.1.2      0010.9400.0002 Dynamic Remote ----
200      90.90.1.3      9819.2c86.3e01 Static Remote  ----
200      90.90.1.4      0010.9400.0005 Dynamic Remote ----

```

Total number of entries are 8

MH-2#

MH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:64512]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	2.2.2.2	MPLS

RD[3.3.3.3:100] VRF[red]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	2.2.2.2	MPLS

RD[3.3.3.3:200] VRF[blue]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	2.2.2.2	MPLS

RD[3.3.3.3:64512] VRF[evpn-gvrf-1]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	3.3.3.3	MPLS

MH-2#

MH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	2.2.2.2	MPLS

RD[2.2.2.2:200]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	2.2.2.2	MPLS

RD[3.3.3.3:100] VRF[red]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	2.2.2.2	MPLS
00:00:00:11:11:aa:aa:00:00:00	100	17	3.3.3.3	MPLS

RD[3.3.3.3:200] VRF[blue]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	2.2.2.2	MPLS
00:00:00:11:11:aa:aa:00:00:00	200	18	3.3.3.3	MPLS

MH-2#

MH-2#sh evpn mpls label esi

S - Self
R - Remote

ESI	PE-IP-ADDRESS	ESI-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	19
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (S)	19

MH-2#

MH-2#sh evpn mpls label alias

S - Self
R - Remote

ESI	PE-IP-ADDRESS	TENANT	ALIAS-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	100	17
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	200	18
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (S)	100	17
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (S)	200	18

MH-2#

MH-2#sh bgp l2vpn evpn

BGP table version is 16, local router ID is 3.3.3.3

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]

- 1 - Ethernet Auto-discovery Route
- 2 - MAC/IP Route
- 3 - Inclusive Multicast Route
- 4 - Ethernet Segment Route
- 5 - Prefix Route

Network Encap	Next Hop	Metric	LocPrf	Weight	Path	Peer
RD[10:200]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	2.2.2.2	0	100	0	? 2.2.2.2	MPLS
*>i [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]	2.2.2.2	0	100	0	? 2.2.2.2	MPLS
RD[30:200]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	5.5.5.5	0	100	0	? 5.5.5.5	MPLS
*>i [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]	5.5.5.5	0	100	0	? 5.5.5.5	MPLS
RD[2.2.2.2:100]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]						

```

                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
*>i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
*>i  [3]:[100]:[32,2.2.2.2]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS

RD[2.2.2.2:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
*>i  [3]:[200]:[32,2.2.2.2]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS

RD[2.2.2.2:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS

RD[3.3.3.3:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
*>                3.3.3.3                0        100        32768    i  -----                MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                5.5.5.5                0        100        0    i  5.5.5.5                MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
                5.5.5.5                0        100        0    i  5.5.5.5                MPLS
* i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
*>                3.3.3.3                0        100        32768    i  -----                MPLS
* i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
                5.5.5.5                0        100        0    i  5.5.5.5                MPLS
* i  [3]:[100]:[32,2.2.2.2]
                2.2.2.2                0        100        0    i  2.2.2.2                MPLS
*>                [3]:[100]:[32,3.3.3.3]
                3.3.3.3                0        100        32768    i  -----                MPLS
* i  [3]:[100]:[32,5.5.5.5]

```



```

5.5.5.5          0          100          0    i  5.5.5.5          MPLS

RD[3.3.3.3:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
      2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>    3.3.3.3          0          100          32768    i  -----          MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
      2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
      2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
      2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
      2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>    3.3.3.3          0          100          32768    i  -----          MPLS
* i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [3]:[200]:[32,2.2.2.2]
      2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>    [3]:[200]:[32,3.3.3.3]
      3.3.3.3          0          100          32768    i  -----          MPLS
* i  [3]:[200]:[32,5.5.5.5]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS

RD[3.3.3.3:64512] VRF[evpn-gvrf-1]:
*>    [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
      3.3.3.3          0          100          32768    i  -----          MPLS
* i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
      2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>    [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
      3.3.3.3          0          100          32768    i  -----          MPLS

RD[5.5.5.5:100]
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [3]:[100]:[32,5.5.5.5]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS

RD[5.5.5.5:200]
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]

```

```

                    5.5.5.5                0        100        0    i  5.5.5.5          MPLS
*>i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
                    5.5.5.5                0        100        0    i  5.5.5.5          MPLS
*>i  [3]:[200]:[32,5.5.5.5]
                    5.5.5.5                0        100        0    i  5.5.5.5          MPLS

```

Total number of prefixes 49

MH-2#

MH-2#sh bgp l2vpn evpn prefix-route

RD[10:200]

ESI	Nexthop	Eth-Tag	Encap	Prefix-Length	Router-Mac	IP-Address	GW-IPAddress	L3VNID/LABEL
0	2.2.2.2	0	MPLS	24	e8c5:7a88:1738	80.80.1.0	0.0.0.0	16
0	2.2.2.2	0	MPLS	24	e8c5:7a88:1738	90.90.1.0	0.0.0.0	16

RD[30:200]

ESI	Nexthop	Eth-Tag	Encap	Prefix-Length	Router-Mac	IP-Address	GW-IPAddress	L3VNID/LABEL
0	5.5.5.5	0	MPLS	24	9819:2c86:3e01	80.80.1.0	0.0.0.0	16
0	5.5.5.5	0	MPLS	24	9819:2c86:3e01	90.90.1.0	0.0.0.0	16

MH-2#

MH-2#sh bgp l2vpn evpn summary

BGP router identifier 3.3.3.3, local AS number 65010

BGP table version is 16

1 BGP AS-PATH entries

0 BGP community entries

Neighbor	PfxRcd	AD	MACIP	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
				MCAST	ESI	PREFIX-ROUTE						
2.2.2.2	14	3	6	4	65010	203	207	16	0	0	01:18:08	
5.5.5.5	10	0	6	4	65010	190	202	16	0	0	01:15:43	

Total number of neighbors 2

Total number of Established sessions 2

MH-2#

MH-2#sh ip bgp vrf evpn_anycast

BGP table version is 1, local router ID is 90.90.1.1

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 80.80.1.0/24	0.0.0.0	0	100	32768	?
* i 5.5.5.5	5.5.5.5	0	100	0	?

```

* i          2.2.2.2          0          100          0      ?
*>  90.90.1.0/24  0.0.0.0      0          100      32768  ?
* i          5.5.5.5          0          100          0      ?
* i          2.2.2.2          0          100          0      ?

```

Total number of prefixes 2

MH-2#

MH-2#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
 (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	3				
			2	-	Yes	LSP_DEFAULT	25601
xe10	No	20.20.20.2					
L>	4.4.4.4/32	2	6				
			5	-	Yes	LSP_DEFAULT	3
xe10	No	20.20.20.2					
L>	5.5.5.5/32	5	8				
			7	-	Yes	LSP_DEFAULT	25602
xe10	No	20.20.20.2					
L>	10.10.10.0/24	3	6				
			5	-	Yes	LSP_DEFAULT	3
xe10	No	20.20.20.2					
L>	30.30.30.0/24	4	6				
			5	-	Yes	LSP_DEFAULT	3
xe10	No	20.20.20.2					

MH-2#

MH-2#sh ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
5.5.5.5	xe10	Passive	OPERATIONAL	30	01:15:31
4.4.4.4	xe10	Passive	OPERATIONAL	30	01:17:16

MH-2#

MH-2#sh ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	
Instance ID						
4.4.4.4	1	Full/DR	00:00:33	20.20.20.2	xe10	0

MH-2#

MH-2#sh nvo vxlan l3vni-map

L3VNI	L2VNI	IRB-interface
10000	100	irb100
10000	200	irb200

MH-2#

SH

SH#sh evpn mpls

EVPN-MPLS Information

=====

Codes: NW - Network Port

AC - Access Port

(u) - Untagged

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-
Status	Src-Addr		Dst-Addr				
100	----	L2	NW	----	----	----	-
---	5.5.5.5		2.2.2.2				
100	----	L2	NW	----	----	----	-
---	5.5.5.5		3.3.3.3				
100	----	--	AC	sa9000.100	---	Single Homed Port	---
---	----		----				
200	----	L2	NW	----	----	----	-
---	5.5.5.5		2.2.2.2				
200	----	L2	NW	----	----	----	-
---	5.5.5.5		3.3.3.3				
200	----	--	AC	sa9000.200	---	Single Homed Port	---
---	----		----				
10000	----	L3	NW	----	----	----	-
---	5.5.5.5		2.2.2.2				
10000	----	L3	NW	----	----	----	-
---	5.5.5.5		3.3.3.3				

Total number of entries are 8

SH#

SH#sh evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
=====	=====	=====	=====	=====	=====
5.5.5.5	2.2.2.2	Installed	01:15:49	01:15:49	200
5.5.5.5	2.2.2.2	Installed	01:15:49	01:15:49	100
5.5.5.5	2.2.2.2	Installed	01:25:33	01:25:33	10000
5.5.5.5	3.3.3.3	Installed	01:15:49	01:15:49	200
5.5.5.5	3.3.3.3	Installed	01:15:49	01:15:49	100
5.5.5.5	3.3.3.3	Installed	01:25:33	01:25:33	10000

Total number of entries are 6

SH#

SH#sh evpn mpls mac-table

=====

EVPN MPLS MAC Entries

=====

VNID	Interface	VlanId	In-VlanId	Mac-Addr	VTEP-Ip/ESI	Type
Status	MAC move	AccessPort	Desc			

```

100      ----      ----      ----      0011.2233.4455 2.2.2.2
Static Remote ----- 0      -----
100      irb100      ----      ----      9819.2c86.3e01 5.5.5.5
Static Local ----- 0      -----
100      ----      ----      ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote ----- 0      -----
100      sa9000.100 ----      ----      0010.9400.0004 5.5.5.5
Dynamic Local ----- 0      -----
200      ----      ----      ----      0011.2233.4455 2.2.2.2
Static Remote ----- 0      -----
200      irb200      ----      ----      9819.2c86.3e01 5.5.5.5
Static Local ----- 0      -----
200      ----      ----      ----      0010.9400.0002 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote ----- 0      -----
200      sa9000.200 ----      ----      0010.9400.0005 5.5.5.5
Dynamic Local ----- 0      -----

```

Total number of entries are : 8

SH#

SH#sh evpn mpls arp-cache

MPLS-EVPN ARP-CACHE Information

=====

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
100	80.80.1.1	0011.2233.4455	Static Remote	----	
100	80.80.1.2	0010.9400.0001	Dynamic Remote	----	
100	80.80.1.3	9819.2c86.3e01	Static Local	----	
100	80.80.1.4	0010.9400.0004	Dynamic Local	----	
200	90.90.1.1	0011.2233.4455	Static Remote	----	
200	90.90.1.2	0010.9400.0002	Dynamic Remote	----	
200	90.90.1.3	9819.2c86.3e01	Static Local	----	
200	90.90.1.4	0010.9400.0005	Dynamic Local	----	

Total number of entries are 8

SH#

SH#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:64512]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	2.2.2.2	MPLS

RD[3.3.3.3:64512]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	3.3.3.3	MPLS

RD[5.5.5.5:100] VRF[red]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	3.3.3.3	MPLS
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	2.2.2.2	MPLS

RD[5.5.5.5:200] VRF[blue]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	3.3.3.3	MPLS
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	2.2.2.2	MPLS

SH#

SH#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	2.2.2.2	MPLS

RD[2.2.2.2:200]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	2.2.2.2	MPLS

RD[3.3.3.3:100]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	3.3.3.3	MPLS

RD[3.3.3.3:200]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	3.3.3.3	MPLS

RD[5.5.5.5:100] VRF[red]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	3.3.3.3	MPLS
00:00:00:11:11:aa:aa:00:00:00	100	17	2.2.2.2	MPLS

RD[5.5.5.5:200] VRF[blue]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	3.3.3.3	MPLS
00:00:00:11:11:aa:aa:00:00:00	200	18	2.2.2.2	MPLS

SH#

SH#sh evpn mpls label esi

S - Self

R - Remote

ESI	PE-IP-ADDRESS	ESI-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	19
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (R)	19

SH#

SH#sh evpn mpls label alias

S - Self

R - Remote

ESI	PE-IP-ADDRESS	TENANT	ALIAS-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	100	17
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	200	18
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (R)	100	17

00:00:00:11:11:aa:aa:00:00:00 3.3.3.3(R) 200 18

SH#

SH#sh bgp l2vpn evpn

BGP table version is 6, local router ID is 5.5.5.5

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]

1 - Ethernet Auto-discovery Route

2 - MAC/IP Route

3 - Inclusive Multicast Route

4 - Ethernet Segment Route

5 - Prefix Route

Network Encap	Next Hop	Metric	LocPrf	Weight	Path	Peer
RD[10:200]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	2.2.2.2	0	100	0	? 2.2.2.2	MPLS
*>i [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]	2.2.2.2	0	100	0	? 2.2.2.2	MPLS
RD[20:200]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	3.3.3.3	0	100	0	? 3.3.3.3	MPLS
*>i [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]	3.3.3.3	0	100	0	? 3.3.3.3	MPLS
RD[2.2.2.2:100]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [3]:[100]:[32,2.2.2.2]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
RD[2.2.2.2:200]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]						

```

                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>i  [3]:[200]:[32,2.2.2.2]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS

RD[2.2.2.2:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS

RD[3.3.3.3:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [3]:[100]:[32,3.3.3.3]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [3]:[200]:[32,3.3.3.3]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[5.5.5.5:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                5.5.5.5          0          100          32768  i  -----          MPLS
*>  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
                5.5.5.5          0          100          32768  i  -----          MPLS
* i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS

```



```
*> [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
      5.5.5.5          0          100          32768 i ----- MPLS
* i [3]:[100]:[32,2.2.2.2]
      2.2.2.2          0          100          0 i 2.2.2.2 MPLS
* i [3]:[100]:[32,3.3.3.3]
      3.3.3.3          0          100          0 i 3.3.3.3 MPLS
*> [3]:[100]:[32,5.5.5.5]
      5.5.5.5          0          100          32768 i ----- MPLS

RD[5.5.5.5:200] VRF[blue]:
* i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
      3.3.3.3          0          100          0 i 3.3.3.3 MPLS
* i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
      2.2.2.2          0          100          0 i 2.2.2.2 MPLS
* i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
      3.3.3.3          0          100          0 i 3.3.3.3 MPLS
* i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
      2.2.2.2          0          100          0 i 2.2.2.2 MPLS
* i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
      2.2.2.2          0          100          0 i 2.2.2.2 MPLS
* i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
      2.2.2.2          0          100          0 i 2.2.2.2 MPLS
*> [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
      5.5.5.5          0          100          32768 i ----- MPLS
*> [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
      5.5.5.5          0          100          32768 i ----- MPLS
* i [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
      3.3.3.3          0          100          0 i 3.3.3.3 MPLS
* i [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
      2.2.2.2          0          100          0 i 2.2.2.2 MPLS
*> [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
      5.5.5.5          0          100          32768 i ----- MPLS
* i [3]:[200]:[32,2.2.2.2]
      2.2.2.2          0          100          0 i 2.2.2.2 MPLS
* i [3]:[200]:[32,3.3.3.3]
      3.3.3.3          0          100          0 i 3.3.3.3 MPLS
*> [3]:[200]:[32,5.5.5.5]
      5.5.5.5          0          100          32768 i ----- MPLS
```

Total number of prefixes 46

SH#

SH#sh bgp l2vpn evpn prefix-route

RD[10:200]

ESI	Eth-Tag	Prefix-Length	IP-Address	GW-IPAddress	L3VNID/LABEL
Nexthop	Encap	Router-Mac			
0	0	24	80.80.1.0	0.0.0.0	16
2.2.2.2	MPLS	e8c5:7a88:1738			
0	0	24	90.90.1.0	0.0.0.0	16
2.2.2.2	MPLS	e8c5:7a88:1738			

RD[20:200]

ESI	Eth-Tag	Prefix-Length	IP-Address	GW-IPAddress	L3VNID/LABEL
Nexthop	Encap	Router-Mac			

```

0          0          24          80.80.1.0          0.0.0.0          16
3.3.3.3    MPLS      e8c5:7ad2:5d98
0          0          24          90.90.1.0          0.0.0.0          16
3.3.3.3    MPLS      e8c5:7ad2:5d98

```

SH#

SH#sh bgp l2vpn evpn summary

BGP router identifier 5.5.5.5, local AS number 65010

BGP table version is 6

1 BGP AS-PATH entries

0 BGP community entries

Neighbor PfxRcd	AD	MACIP	V MCAST	AS	MsgRcv ESI	MsgSen PREFIX-ROUTE	TblVer	InQ	OutQ	Up/Down	State/
2.2.2.2			4	65010	198	189	5	0	0	01:15:56	
14	3	6	2	1	2						
3.3.3.3			4	65010	203	191	5	0	0	01:15:55	
10	3	2	2	1	2						

Total number of neighbors 2

Total number of Established sessions 2

SH#

SH#sh ip bgp vrf evpn_anycast

BGP table version is 1, local router ID is 90.90.1.3

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 80.80.1.0/24	0.0.0.0	0	100	32768	?
* i	3.3.3.3	0	100	0	?
* i	2.2.2.2	0	100	0	?
*> 90.90.1.0/24	0.0.0.0	0	100	32768	?
* i	3.3.3.3	0	100	0	?
* i	2.2.2.2	0	100	0	?

Total number of prefixes 2

SH#

SH#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

(m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	3				
			2	-	Yes	LSP_DEFAULT	25604
xe6	No	30.30.30.2					
L>	3.3.3.3/32	2	6				

```

xe6          No    30.30.30.2      5      -      Yes    LSP_DEFAULT  25605
L>  4.4.4.4/32      3      9
8      -      Yes    LSP_DEFAULT  3
xe6          No    30.30.30.2      8
L>  10.10.10.0/24    4      9
8      -      Yes    LSP_DEFAULT  3
xe6          No    30.30.30.2      8
L>  20.20.20.0/24    5      9
8      -      Yes    LSP_DEFAULT  3
xe6          No    30.30.30.2      8

```

SH#

SH#sh ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe6	Active	OPERATIONAL	30	01:15:46
3.3.3.3	xe6	Active	OPERATIONAL	30	01:15:44
4.4.4.4	xe6	Active	OPERATIONAL	30	01:15:51

SH#

SH#sh ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
4.4.4.4	1	Full/DR	00:00:33	30.30.30.2	xe6	0

SH#

SH#sh nvo vxlan l3vni-map

L3VNI	L2VNI	IRB-interface
10000	100	irb100
10000	200	irb200

SH#

P1

P1#sh ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
3.3.3.3	xe1	Active	OPERATIONAL	30	01:21:33
2.2.2.2	xe4.1	Active	OPERATIONAL	30	01:21:35
5.5.5.5	xe6	Passive	OPERATIONAL	30	01:19:55

P1#

P1#sh ip ospf neighbor

Total number of full neighbors: 3

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
2.2.2.2 0	1	Full/Backup	00:00:37	10.10.10.1	xe4.1	
3.3.3.3	1	Full/Backup	00:00:35	20.20.20.1	xe1	0
5.5.5.5	1	Full/Backup	00:00:35	30.30.30.1	xe6	0

```

P1#
P1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

```

Label	Code	FEC Out-Intf	ELC	Nexthop	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-
	L>	2.2.2.2/32			1	2				
xe4.1		No	10.10.10.1		1	-	Yes	LSP_DEFAULT	3	
	L>	3.3.3.3/32			2	4				
					3	-	Yes	LSP_DEFAULT	3	
xe1		No	20.20.20.1							
	L>	5.5.5.5/32			3	8				
					7	-	Yes	LSP_DEFAULT	3	
xe6		No	30.30.30.1							

```

P1#

```

EVPN MPLS IRB Asymmetric Anycast mode

Topology:

Refer [Figure 2-4](#) depicts the EVPN MPLS IRB with LDP as underlay MPLS path.

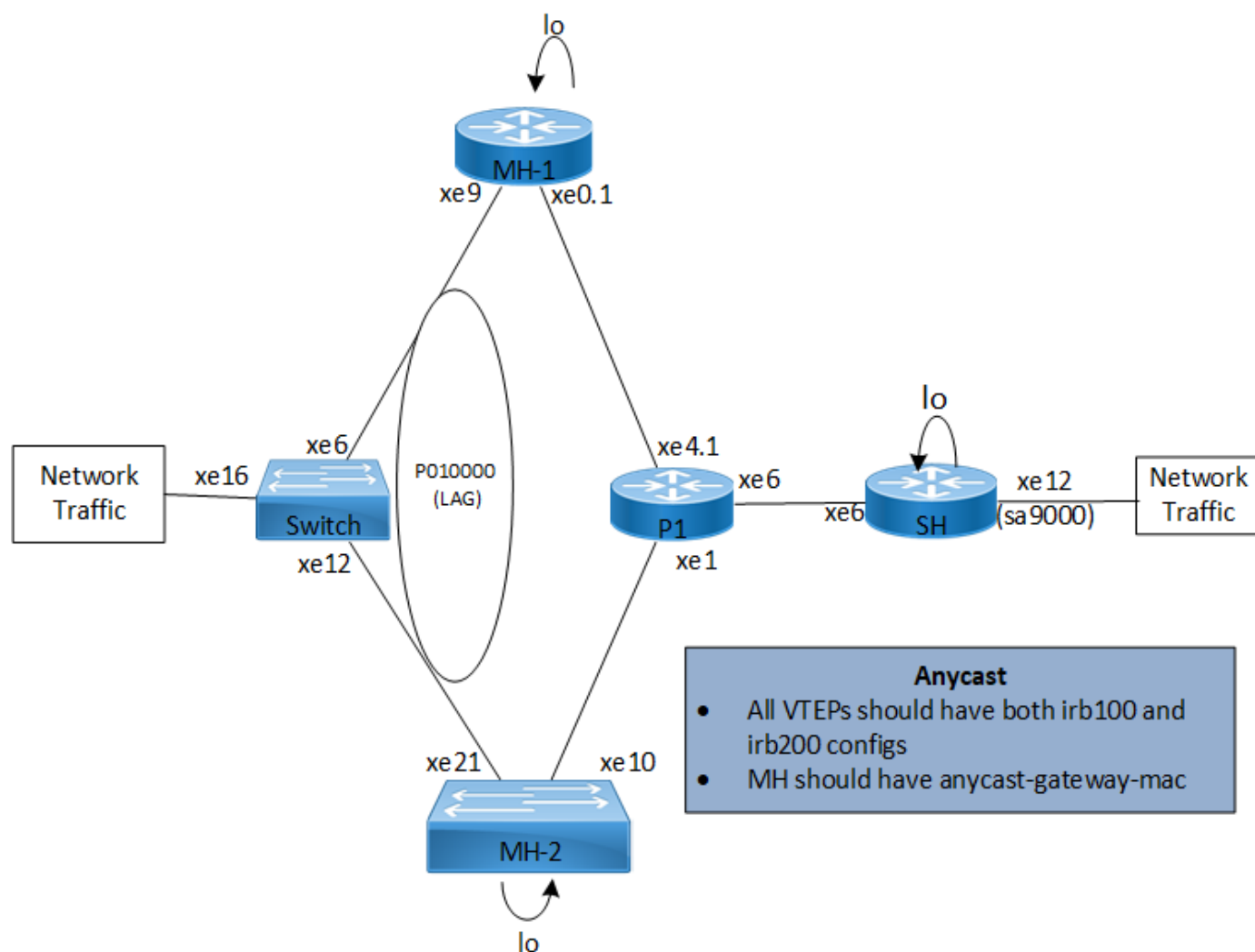


Figure 2-4: EVPN MPLS IRB Asymmetric Anycast mode

Configuration

SH

Enable EVPN MPLS and IRB:

#configure terminal	Enter configuration mode.
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally

Loopback Interface:

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 5.5.5.5/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF:

(config)#mac vrf red	Create MAC VRF red.
(config-vrf)# rd 5.5.5.5:100	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode
(config)#mac vrf blue	Create MAC VRF blue.
(config-vrf)# rd 5.5.5.5:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF:

(config)#ip vrf evpn_anycast	Configure IP VRF evpn.
(config-vrf)# rd 30:200	Configure route distinguisher
(config-vrf)# route-target both 100:200	Configure route target
(config-vrf)# l3vni 10000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configuring IRB interface:

(config)#interface irb100	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding evpn_anycast	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 80.80.1.3/24 anycast	Assign IP address
(config-irb-if)#exit	Exit interface mode
(config)#interface irb200	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding evpn_anycast	Map L3 VRF to the IRB interface

(config-irb-if)# ip address 90.90.1.3/24 anycast	Assign IP address
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID:

(config)#evpn mpls vtep-ip-global 5.5.5.5	Configure VTEP global IP
(config)#evpn mpls id 100	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachability- protocol evpn-bgp red	Map the MAC VRF red
(config-evpn-mpls)# evpn irb irb100	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode
(config)#evpn mpls id 200	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachability- protocol evpn-bgp blue	Map the MAC VRF blue
(config-evpn-mpls)# evpn irb irb200	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 5.5.5.5	Enter LDP router-id
(config-router)# transport-address ipv4 5.5.5.5	Configure LDP transport address
(config-router)# targeted-peer ipv4 2.2.2.2	Configure LDP target peer address (MH-1)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 3.3.3.3	Configure LDP target peer address (MH-2)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side:

(config-if)#interface xe6	Enter interface mode
(config-if)# description connected to P1	Configure interface description
(config-if)# ip address 30.30.30.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#ospf router-id 5.5.5.5	Configure OSPF router id
(config-router)# network 5.5.5.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit OSPF mode

BGP Configuration:

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring MH-1 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 3.3.3.3 remote-as 65010	Configuring MH-2 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 3.3.3.3 update-source lo	Source of routing updates as loopback
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 2.2.2.2 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 3.3.3.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf evpn_anycast	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration:

(config-if)#interface sa9000	Creating Static LAG interface
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)#exit	Exiting out of interface mode
(config-if)#interface sa9000.100 switchport	Creating Static LAG L2 sub interface of physical interface xe12
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)#map vpn-id 100	Map VPN-ID 100
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config-if)#interface sa9000.200 switchport	Creating Static LAG L2 sub interface of physical interface xe12
(config-if)# encapsulation dot1q 200	Setting Encapsulation to dot1q with VLAN ID 200
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)#map vpn-id 200	Map VPN-ID 200
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config-if)#interface xe12	Enter the Interface mode
(config-if)# static-channel-group 9000	Map the physical interface xe12 as static LAG member
(config-if)#exit	Exit interface mode

P1:**Loopback Interface:**

#configure terminal	Enter configuration mode.
(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 4.4.4.4/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)# router-id 4.4.4.4	Configure router id
(config-router)# transport-address ipv4 4.4.4.4	Configure transport address
(config-router)#exit	Exit from LDP mode

Interface Configuration:

(config-if)#interface xe4	Enter the Interface mode for xe4.
(config-if)# mtu 9216	Configure MTU.
(config-if)#exit	Enable LDP on the physical interface
(config)#interface xe4.1	Create sub-interface xe4.1.
(config-if)# description connected-to-MH-1	Configure Interface description
(config-if)# ip address 10.10.10.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# encapsulation dot1q 20	Configure encapsulation as dotq
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter into Interface mode
(config-if)# description connected to MH-2	Configure Interface description
(config-if)# ip address 20.20.20.2/24	Configure IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe6	Enter into Interface mode
(config-if)# description connected to SH	Configure Interface description
(config-if)# ip address 30.30.30.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 4.4.4.4	Setting the Router ID as Loopback IP
(config-router)# network 4.4.4.4/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.10.10.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)# network 20.20.20.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.

(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

MH-1:**Enable EVPN MPLS and IRB:**

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mpls-mh enable	Configure hardware profile to enable EVPN MPLS multihoming in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface:

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 2.2.2.2/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF:

(config)#mac vrf red	Create MAC VRF red.
(config-vrf)# rd 2.2.2.2:100	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode
(config)#mac vrf blue	Create MAC VRF blue.
(config-vrf)# rd 2.2.2.2:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF:

(config)#ip vrf evpn_anycast	Configure IP VRF evpn.
(config-vrf)# rd 10:200	Configure route distinguisher
(config-vrf)# route-target both 100:200	Configure route target
(config-vrf)# l3vni 10000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configure Anycast Gateway MAC:

(config)#evpn irb-forwarding anycast-gateway- mac 0011.2233.4455	Configure anycast gateway MAC globally
(config)#interface irb100	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding evpn	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 80.80.1.1/24 anycast	Assign IP address
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode
(config)#interface irb200	Create IRB interface irb200
(config-irb-if)# ip vrf forwarding evpn	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 90.90.1.1/24 anycast	Assign IP address
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID:

(config)#evpn mpls vtep-ip-global 2.2.2.2	Configure VTEP global IP
(config)#evpn mpls id 100	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp red	Map the MAC VRF red
(config-evpn-mpls)# evpn irb irb100	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode
(config)#evpn mpls id 200	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp blue	Map the MAC VRF blue
(config-evpn-mpls)# evpn irb irb200	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 2.2.2.2	Enter LDP router-id
(config-router)# transport-address ipv4 2.2.2.2	Configure LDP transport address
(config-router)# targeted-peer ipv4 5.5.5.5	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side:

(config-if)#interface xe0	Enter the Interface mode for xe0.
(config-if)# mtu 9216	Configure MTU.
(config-if)#exit	Exit from interface xe0
(config)#interface xe0.1	Create subinterface in xe10
(config-if)# encapsulation dot1q 20	Configure encapsulation as dotq
(config-if)# ip address 10.10.10.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 2.2.2.2	Router-ID configurations
(config-router)# network 2.2.2.2/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.10.10.0/24 area 0.0.0.0	Advertise network address in OSPF.

BGP Configuration:

(config-router)#router bgp 65010	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 3.3.3.3 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 3.3.3.3 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 5.5.5.5 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 3.3.3.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 5.5.5.5 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf evpn	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration:

(config)#interface xe9	Enter configuration mode
(config-if)# mtu 9216	Configure MTU
(config-if)# channel-group 10000 mode active	Configure physical interface xe9 as LAG member po10000
(config-if)#exit	Exit from interface xe9
(config)#interface po10000	Create LAG interface po10000
(config-if)# mtu 9216	Configure MTU
(config-if)# description connected to Switch	Configure Interface description
(config-if)# evpn multi-homed system-mac 0000.1111.aaaa	Configure system MAC for multi homing
(config)#interface po10000.100 switchport	Creating L2 sub interface of physical interface xe9
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 100	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config)#interface po10000.200 switchport	Creating L2 sub interface of physical interface xe9

(config-if)# encapsulation dot1q 200	Setting Encapsulation to dot1q with VLAN ID 200
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 200	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode

MH-2:**Enable EVPN MPLS and IRB:**

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mpls-mh enable	Configure hardware profile to enable EVPN MPLS multihoming in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface:

(config-if)#interface lo	Enter the Interface mode for the loopback interface
(config-if)# ip address 3.3.3.3/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF:

(config)#mac vrf red	Create MAC VRF red.
(config-vrf)# rd 3.3.3.3:100	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode
(config)#mac vrf blue	Create MAC VRF blue.
(config-vrf)# rd 3.3.3.3:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF:

(config)#ip vrf evpn_anycast	Configure IP VRF evpn.
(config-vrf)# rd 20:200	Configure route distinguisher
(config-vrf)# route-target both 100:200	Configure route target
(config-vrf)# l3vni 10000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configure Anycast Gateway MAC:

(config)#evpn irb-forwarding anycastgateway-mac 0011.2233.4455	Configure anycast gateway MAC globally
--	--

Configuring IRB interface:

(config)#interface irb100	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding evpn	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 80.80.1.1/24 anycast	Assign IP address
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode
(config)#interface irb200	Create IRB interface irb200
(config-irb-if)# ip vrf forwarding evpn	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 90.90.1.1/24 anycast	Assign IP address
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID:

(config)#evpn mpls vtep-ip-global 3.3.3.3	Configure VTEP global IP
(config)#evpn mpls id 100	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp red	Map the MAC VRF red
(config-evpn-mpls)# evpn irb irb100	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode
(config)#evpn mpls id 200	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp blue	Map the MAC VRF blue
(config-evpn-mpls)# evpn irb irb200	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)# transport-address ipv4 3.3.3.3	Configure LDP transport address
(config-router)# targeted-peer ipv4 5.5.5.5	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side:

(config-if)#interface xe10	Enter the configuration mode.
(config-if)# description connected to P1	Configure Interface description
(config-if)# ip address 20.20.20.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 3.3.3.3	Router-ID configurations
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 20.20.20.0/24 area 0.0.0.0	Advertise network address in OSPF.

BGP Configuration:

(config-router)#router bgp 65010	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 5.5.5.5 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 2.2.2.2 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 5.5.5.5 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf evpn_anycast	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration:

(config)#interface xe21	Enter configuration mode
(config-if)# mtu 9216	Configure MTU
(config-if)# channel-group 10000 mode active	Configure physical interface xe21 as LAG member po10000
(config-if)#exit	Exit from interface xe21
(config)#interface po10000	Create LAG interface po10000
(config-if)# mtu 9216	Configure MTU
(config-if)# description connected to Switch	Configure Interface description
(config-if)# evpn multi-homed system-mac 0000.1111.aaaa	Configure system MAC for multi homing
(config)#interface po10000.100 switchport	Creating L2 sub interface of physical interface xe21
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 100	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config)#interface po10000.200 switchport	Creating L2 sub interface of physical interface xe21
(config-if)# encapsulation dot1q 200	Setting Encapsulation to dot1q with VLAN ID 200
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 200	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode

Validation

Note: Remote entries cannot be fetched from through MAC table/ARP cache/ND cache. However they can be fetched from the BGP table.

MH-1:

```
MH-1#sh evpn mpls
EVPN-MPLS Information
```

```
=====
```

```
Codes: NW - Network Port
        AC - Access Port
        (u) - Untagged
```

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-
Status	Src-Addr			Dst-Addr			

```

100      ----      L2      NW      ----      ----      ----      -
---      2.2.2.2      3.3.3.3
100      ----      L2      NW      ----      ----      ----      -
---      2.2.2.2      5.5.5.5
100      ----      --      AC      po10000.100 00:00:00:11:11:aa:aa:00:00:00 ----      DF
-----
200      ----      L2      NW      ----      ----      ----      -
---      2.2.2.2      3.3.3.3
200      ----      L2      NW      ----      ----      ----      -
---      2.2.2.2      5.5.5.5
200      ----      --      AC      po10000.200 00:00:00:11:11:aa:aa:00:00:00 ----      DF
-----
10000     ----      L3      NW      ----      ----      ----      -
---      2.2.2.2      3.3.3.3
10000     ----      L3      NW      ----      ----      ----      -
---      2.2.2.2      5.5.5.5

```

Total number of entries are 8

MH-1#

MH-1#sh evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
2.2.2.2	3.3.3.3	Installed	01:16:34	01:16:34	200
2.2.2.2	3.3.3.3	Installed	01:16:34	01:16:34	100
2.2.2.2	3.3.3.3	Installed	01:23:48	01:23:48	10000
2.2.2.2	5.5.5.5	Installed	01:14:59	01:14:59	200
2.2.2.2	5.5.5.5	Installed	01:14:59	01:14:59	100
2.2.2.2	5.5.5.5	Installed	01:23:48	01:23:48	10000

Total number of entries are 6

MH-1#

MH-1#sh evpn mpls mac-table

```

=====
                                     EVPN MPLS MAC Entries
=====
VNID      Interface VlanId  In-VlanId Mac-Addr      VTEP-Ip/ESI      Type
Status      MAC move AccessPortDesc
-----
100      irb100      ----      ----      0011.2233.4455 2.2.2.2
Static Local      -----      0      -----
100      ----      ----      ----      9819.2c86.3e01 5.5.5.5
Static Remote      -----      0      -----
100      po10000.100 ----      ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Local      -----      0      -----
100      ----      ----      ----      0010.9400.0004 5.5.5.5
Dynamic Remote      -----      0      -----
200      irb200      ----      ----      0011.2233.4455 2.2.2.2
Static Local      -----      0      -----

```

```

200      ----      ----      ----      9819.2c86.3e01 5.5.5.5
Static Remote      -----      0      -----
200      po10000.200 ----      ----      0010.9400.0002 00:00:00:11:11:aa:aa:00:00:00
Dynamic Local      -----      0      -----
200      ----      ----      ----      0010.9400.0005 5.5.5.5
Dynamic Remote      -----      0      -----

```

Total number of entries are : 8

MH-1#

MH-1#sh evpn mpls arp-cache

MPLS-EVPN ARP-CACHE Information

=====

ARP Timeout : 300 sec Random-Jitter-Max : 200

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
100	80.80.1.1	0011.2233.4455	Static Local	----	
100	80.80.1.2	0010.9400.0001	Dynamic Local	244	2
100	80.80.1.3	9819.2c86.3e01	Static Remote	----	
100	80.80.1.4	0010.9400.0004	Dynamic Remote	----	
200	90.90.1.1	0011.2233.4455	Static Local	----	
200	90.90.1.2	0010.9400.0002	Dynamic Local	----	
200	90.90.1.3	9819.2c86.3e01	Static Remote	----	
200	90.90.1.4	0010.9400.0005	Dynamic Remote	----	

Total number of entries are 8

MH-1#

MH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:100] VRF[red]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	3.3.3.3	MPLS

RD[2.2.2.2:200] VRF[blue]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	3.3.3.3	MPLS

RD[2.2.2.2:64512] VRF[evpn-gvrf-1]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	2.2.2.2	MPLS

RD[3.3.3.3:64512]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	3.3.3.3	MPLS

MH-1#

MH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100] VRF[red]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	3.3.3.3	MPLS
00:00:00:11:11:aa:aa:00:00:00	100	17	2.2.2.2	MPLS

RD[2.2.2.2:200] VRF[blue]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	3.3.3.3	MPLS
00:00:00:11:11:aa:aa:00:00:00	200	18	2.2.2.2	MPLS

RD[3.3.3.3:100]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	3.3.3.3	MPLS

RD[3.3.3.3:200]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	3.3.3.3	MPLS

MH-1#

MH-1#sh evpn mpls label esi

S - Self

R - Remote

ESI	PE-IP-ADDRESS	ESI-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (S)	19
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (R)	19

MH-1#

MH-1#sh evpn mpls label alias

S - Self

R - Remote

ESI	PE-IP-ADDRESS	TENANT	ALIAS-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (S)	100	17
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (S)	200	18
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (R)	100	17
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (R)	200	18

MH-1#

MH-1#sh bgp l2vpn evpn

BGP table version is 10, local router ID is 2.2.2.2

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]

1 - Ethernet Auto-discovery Route

2 - MAC/IP Route

3 - Inclusive Multicast Route

4 - Ethernet Segment Route

5 - Prefix Route

Network	Next Hop	Metric	LocPrf	Weight	Path	Peer
Encap						

RD[20:200]

```

*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
      3.3.3.3          0          100          0    ?  3.3.3.3          MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
      3.3.3.3          0          100          0    ?  3.3.3.3          MPLS

RD[30:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
      5.5.5.5          0          100          0    ?  5.5.5.5          MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
      5.5.5.5          0          100          0    ?  5.5.5.5          MPLS

RD[2.2.2.2:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>      2.2.2.2          0          100          32768  i  -----          MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*> [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
      2.2.2.2          0          100          32768  i  -----          MPLS
*> [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
      2.2.2.2          0          100          32768  i  -----          MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>      2.2.2.2          0          100          32768  i  -----          MPLS
* i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*> [3]:[100]:[32,2.2.2.2]
      2.2.2.2          0          100          32768  i  -----          MPLS
* i  [3]:[100]:[32,3.3.3.3]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [3]:[100]:[32,5.5.5.5]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS

RD[2.2.2.2:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>      2.2.2.2          0          100          32768  i  -----          MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*> [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
      2.2.2.2          0          100          32768  i  -----          MPLS
*> [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
      2.2.2.2          0          100          32768  i  -----          MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]

```

```

5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>      2.2.2.2          0          100          32768    i  -----          MPLS
* i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>      [3]:[200]:[32,2.2.2.2]
      2.2.2.2          0          100          32768    i  -----          MPLS
* i  [3]:[200]:[32,3.3.3.3]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [3]:[200]:[32,5.5.5.5]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS

RD[2.2.2.2:64512] VRF[evpn-gvrf-1]:
*>      [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
      2.2.2.2          0          100          32768    i  -----          MPLS
*>      [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
      2.2.2.2          0          100          32768    i  -----          MPLS
* i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [3]:[100]:[32,3.3.3.3]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [3]:[200]:[32,3.3.3.3]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
      3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[5.5.5.5:100]
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS

```



```
*>i  [3]:[100]:[32,5.5.5.5]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS

RD[5.5.5.5:200]
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [3]:[200]:[32,5.5.5.5]
      5.5.5.5          0          100          0    i  5.5.5.5          MPLS
```

Total number of prefixes 45

MH-1#

MH-1#sh bgp l2vpn evpn prefix-route

```
RD[20:200]
ESI      Eth-Tag Prefix-Length IP-Address  GW-IPAddress  L3VNID/LABEL
Nexthop  Encap    Router-Mac
0        0      24          80.80.1.0    0.0.0.0       16
3.3.3.3  MPLS    e8c5:7ad2:5d98
0        0      24          90.90.1.0    0.0.0.0       16
3.3.3.3  MPLS    e8c5:7ad2:5d98
```

```
RD[30:200]
ESI      Eth-Tag Prefix-Length IP-Address  GW-IPAddress  L3VNID/LABEL
Nexthop  Encap    Router-Mac
0        0      24          80.80.1.0    0.0.0.0       16
5.5.5.5  MPLS    9819:2c86:3e01
0        0      24          90.90.1.0    0.0.0.0       16
5.5.5.5  MPLS    9819:2c86:3e01
```

MH-1#

MH-1#sh bgp l2vpn evpn summary

BGP router identifier 2.2.2.2, local AS number 65010

BGP table version is 10

1 BGP AS-PATH entries

0 BGP community entries

Neighbor	AD	MACIP	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
PfxRcd			MC	CAST	ESI	PREFIX-ROUTE					
3.3.3.3			4	65010	205	203	9	0	0	01:17:25	
10	3	2	2	1	2						
5.5.5.5			4	65010	187	197	9	0	0	01:15:01	
10	0	6	2	0	2						

Total number of neighbors 2

Total number of Established sessions 2

MH-1#

MH-1#sh ip bgp vrf evpn_anycast

BGP table version is 1, local router ID is 90.90.1.1

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 80.80.1.0/24	0.0.0.0	0	100	32768	?
* i	5.5.5.5	0	100	0	?
* i	3.3.3.3	0	100	0	?
*> 90.90.1.0/24	0.0.0.0	0	100	32768	?
* i	5.5.5.5	0	100	0	?
* i	3.3.3.3	0	100	0	?

Total number of prefixes 2

MH-1#

MH-1#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
 (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	3.3.3.3/32	1	3				
			2	-	Yes	LSP_DEFAULT	25600
xe0.1	No	10.10.10.2					
L>	4.4.4.4/32	2	6				
			5	-	Yes	LSP_DEFAULT	3
xe0.1	No	10.10.10.2					
L>	5.5.5.5/32	5	8				
			7	-	Yes	LSP_DEFAULT	25603
xe0.1	No	10.10.10.2					
L>	20.20.20.0/24	3	6				
			5	-	Yes	LSP_DEFAULT	3
xe0.1	No	10.10.10.2					
L>	30.30.30.0/24	4	6				
			5	-	Yes	LSP_DEFAULT	3
xe0.1	No	10.10.10.2					

MH-1#

MH-1#sh ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
5.5.5.5	xe0.1	Passive	OPERATIONAL	30	01:14:50
4.4.4.4	xe0.1	Passive	OPERATIONAL	30	01:16:35

MH-1#

MH-1#sh ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	
Instance ID						
4.4.4.4	1	Full/DR	00:00:39	10.10.10.2	xe0.1	0

```
MH-1#
MH-1#sh nvo vxlan l3vni-map
  L3VNI          L2VNI          IRB-interface
=====
  10000          100            irb100
  10000          200            irb200
```

MH-1#

MH-2:

```
MH-2#sh evpn mpls
EVPN-MPLS Information
=====
```

```
Codes: NW - Network Port
       AC - Access Port
       (u) - Untagged
```

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-
Status	Src-Addr		Dst-Addr				
100	----	L2	NW	----	----	----	-
---	3.3.3.3		5.5.5.5				
100	----	L2	NW	----	----	----	-
---	3.3.3.3		2.2.2.2				
100	----	--	AC	po10000.100	00:00:00:11:11:aa:aa:00:00:00	----	
NON-DF	----		----				
200	----	L2	NW	----	----	----	-
---	3.3.3.3		5.5.5.5				
200	----	L2	NW	----	----	----	-
---	3.3.3.3		2.2.2.2				
200	----	--	AC	po10000.200	00:00:00:11:11:aa:aa:00:00:00	----	
NON-DF	----		----				
10000	----	L3	NW	----	----	----	-
---	3.3.3.3		5.5.5.5				
10000	----	L3	NW	----	----	----	-
---	3.3.3.3		2.2.2.2				

Total number of entries are 8

MH-2#

```
MH-2#sh evpn mpls tunnel
```

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
=====	=====	=====	=====	=====	=====
3.3.3.3	5.5.5.5	Installed	01:15:41	01:15:41	200
3.3.3.3	5.5.5.5	Installed	01:15:41	01:15:41	100
3.3.3.3	5.5.5.5	Installed	01:24:08	01:24:08	10000
3.3.3.3	2.2.2.2	Installed	01:17:15	01:17:15	200
3.3.3.3	2.2.2.2	Installed	01:17:15	01:17:15	100
3.3.3.3	2.2.2.2	Installed	01:24:08	01:24:08	10000

Total number of entries are 6

MH-2#

MH-2#sh evpn mpls mac-table

EVPN MPLS MAC Entries						
VNID	Interface	VlanId	In-VlanId	Mac-Addr	VTEP-Ip/ESI	Type
Status	MAC move	AccessPort	Desc			
100	irb100	----	----	0011.2233.4455	3.3.3.3	
Static Local	-----	0	-----			
100	----	----	----	9819.2c86.3e01	5.5.5.5	
Static Remote	-----	0	-----			
100	----	----	----	0010.9400.0001	00:00:00:11:11:aa:aa:00:00:00	
Dynamic Remote	-----	0	-----			
100	----	----	----	0010.9400.0004	5.5.5.5	
Dynamic Remote	-----	0	-----			
200	irb200	----	----	0011.2233.4455	3.3.3.3	
Static Local	-----	0	-----			
200	----	----	----	9819.2c86.3e01	5.5.5.5	
Static Remote	-----	0	-----			
200	----	----	----	0010.9400.0002	00:00:00:11:11:aa:aa:00:00:00	
Dynamic Remote	-----	0	-----			
200	----	----	----	0010.9400.0005	5.5.5.5	
Dynamic Remote	-----	0	-----			

Total number of entries are : 8

MH-2#

MH-2#sh evpn mpls arp-cache

MPLS-EVPN ARP-CACHE Information

=====

ARP Timeout : 300 sec Random-Jitter-Max : 200

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
100	80.80.1.1	0011.2233.4455	Static Local	----	
100	80.80.1.2	0010.9400.0001	Dynamic Remote	----	
100	80.80.1.3	9819.2c86.3e01	Static Remote	----	
100	80.80.1.4	0010.9400.0004	Dynamic Remote	----	
200	90.90.1.1	0011.2233.4455	Static Local	----	
200	90.90.1.2	0010.9400.0002	Dynamic Remote	----	
200	90.90.1.3	9819.2c86.3e01	Static Remote	----	
200	90.90.1.4	0010.9400.0005	Dynamic Remote	----	

Total number of entries are 8

MH-2#

MH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-es

```
RD[2.2.2.2:64512]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19          2.2.2.2     MPLS
```

```
RD[3.3.3.3:100] VRF[red]:
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19          2.2.2.2     MPLS
```

```
RD[3.3.3.3:200] VRF[blue]:
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19          2.2.2.2     MPLS
```

```
RD[3.3.3.3:64512] VRF[evpn-gvrf-1]:
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19          3.3.3.3     MPLS
```

```
MH-2#
MH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-evi
```

```
RD[2.2.2.2:100]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap
00:00:00:11:11:aa:aa:00:00:00  100        17          2.2.2.2     MPLS
```

```
RD[2.2.2.2:200]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap
00:00:00:11:11:aa:aa:00:00:00  200        18          2.2.2.2     MPLS
```

```
RD[3.3.3.3:100] VRF[red]:
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap
00:00:00:11:11:aa:aa:00:00:00  100        17          2.2.2.2     MPLS
00:00:00:11:11:aa:aa:00:00:00  100        17          3.3.3.3     MPLS
```

```
RD[3.3.3.3:200] VRF[blue]:
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap
00:00:00:11:11:aa:aa:00:00:00  200        18          2.2.2.2     MPLS
00:00:00:11:11:aa:aa:00:00:00  200        18          3.3.3.3     MPLS
```

```
MH-2#
MH-2#sh evpn mpls label esi
```

```
S - Self
R - Remote
```

ESI	PE-IP-ADDRESS	ESI-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	19
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (S)	19

```
MH-2#
MH-2#sh evpn mpls label alias
```

```
S - Self
R - Remote
```

ESI	PE-IP-ADDRESS	TENANT	ALIAS-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	100	17

```
00:00:00:11:11:aa:aa:00:00:00 2.2.2.2(R) 200 18
00:00:00:11:11:aa:aa:00:00:00 3.3.3.3(S) 100 17
00:00:00:11:11:aa:aa:00:00:00 3.3.3.3(S) 200 18
```

MH-2#

MH-2#sh bgp l2vpn evpn

BGP table version is 16, local router ID is 3.3.3.3

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]

1 - Ethernet Auto-discovery Route

2 - MAC/IP Route

3 - Inclusive Multicast Route

4 - Ethernet Segment Route

5 - Prefix Route

Network Encap	Next Hop	Metric	LocPrf	Weight	Path	Peer
RD[10:200]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	2.2.2.2	0	100	0	? 2.2.2.2	MPLS
*>i [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]	2.2.2.2	0	100	0	? 2.2.2.2	MPLS
RD[30:200]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	5.5.5.5	0	100	0	? 5.5.5.5	MPLS
*>i [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]	5.5.5.5	0	100	0	? 5.5.5.5	MPLS
RD[2.2.2.2:100]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [3]:[100]:[32,2.2.2.2]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
RD[2.2.2.2:200]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]						

```

                2.2.2.2                0        100        0    i  2.2.2.2        MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS
*>i  [3]:[200]:[32,2.2.2.2]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS

RD[2.2.2.2:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS

RD[3.3.3.3:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS
*>                3.3.3.3                0        100        32768    i  -----        MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                5.5.5.5                0        100        0    i  5.5.5.5        MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
                5.5.5.5                0        100        0    i  5.5.5.5        MPLS
* i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS
*>                3.3.3.3                0        100        32768    i  -----        MPLS
* i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
                5.5.5.5                0        100        0    i  5.5.5.5        MPLS
* i  [3]:[100]:[32,2.2.2.2]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS
*>  [3]:[100]:[32,3.3.3.3]
                3.3.3.3                0        100        32768    i  -----        MPLS
* i  [3]:[100]:[32,5.5.5.5]
                5.5.5.5                0        100        0    i  5.5.5.5        MPLS

RD[3.3.3.3:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS
*>                3.3.3.3                0        100        32768    i  -----        MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
                2.2.2.2                0        100        0    i  2.2.2.2        MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
                5.5.5.5                0        100        0    i  5.5.5.5        MPLS

```

```

* i [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
    5.5.5.5 0 100 0 i 5.5.5.5 MPLS
* i [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
    2.2.2.2 0 100 0 i 2.2.2.2 MPLS
*> 3.3.3.3 0 100 32768 i ----- MPLS
* i [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
    5.5.5.5 0 100 0 i 5.5.5.5 MPLS
* i [3]:[200]:[32,2.2.2.2]
    2.2.2.2 0 100 0 i 2.2.2.2 MPLS
*> [3]:[200]:[32,3.3.3.3]
    3.3.3.3 0 100 32768 i ----- MPLS
* i [3]:[200]:[32,5.5.5.5]
    5.5.5.5 0 100 0 i 5.5.5.5 MPLS

RD[3.3.3.3:64512] VRF[evpn-gvrf-1]:
*> [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
    3.3.3.3 0 100 32768 i ----- MPLS
* i [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
    2.2.2.2 0 100 0 i 2.2.2.2 MPLS
*> [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
    3.3.3.3 0 100 32768 i ----- MPLS

RD[5.5.5.5:100]
*>i [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
    5.5.5.5 0 100 0 i 5.5.5.5 MPLS
*>i [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
    5.5.5.5 0 100 0 i 5.5.5.5 MPLS
*>i [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
    5.5.5.5 0 100 0 i 5.5.5.5 MPLS
*>i [3]:[100]:[32,5.5.5.5]
    5.5.5.5 0 100 0 i 5.5.5.5 MPLS

RD[5.5.5.5:200]
*>i [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
    5.5.5.5 0 100 0 i 5.5.5.5 MPLS
*>i [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
    5.5.5.5 0 100 0 i 5.5.5.5 MPLS
*>i [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
    5.5.5.5 0 100 0 i 5.5.5.5 MPLS
*>i [3]:[200]:[32,5.5.5.5]
    5.5.5.5 0 100 0 i 5.5.5.5 MPLS

```

Total number of prefixes 49

MH-2#

MH-2#sh bgp l2vpn evpn prefix-route

RD[10:200]

ESI	Eth-Tag	Prefix-Length	IP-Address	GW-IPAddress	L3VNID/LABEL
Nexthop	Encap	Router-Mac			
0	0	24	80.80.1.0	0.0.0.0	16
2.2.2.2	MPLS	e8c5:7a88:1738			


```
0          0          24          90.90.1.0          0.0.0.0          16
2.2.2.2    MPLS      e8c5:7a88:1738
```

RD[30:200]

ESI	Eth-Tag	Prefix-Length	IP-Address	GW-IPAddress	L3VNID/LABEL
Nexthop	Encap	Router-Mac			
0	0	24	80.80.1.0	0.0.0.0	16
5.5.5.5	MPLS	9819:2c86:3e01			
0	0	24	90.90.1.0	0.0.0.0	16
5.5.5.5	MPLS	9819:2c86:3e01			

MH-2#

MH-2#sh bgp l2vpn evpn summary

BGP router identifier 3.3.3.3, local AS number 65010

BGP table version is 16

1 BGP AS-PATH entries

0 BGP community entries

Neighbor	AD	MACIP	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
PfxRcd			MCAST		ESI	PREFIX-ROUTE					
2.2.2.2			4	65010	203	207	16	0	0	01:18:08	
14	3	6	2	1	2						
5.5.5.5			4	65010	190	202	16	0	0	01:15:43	
10	0	6	2	0	2						

Total number of neighbors 2

Total number of Established sessions 2

MH-2#

MH-2#sh ip bgp vrf evpn_anycast

BGP table version is 1, local router ID is 90.90.1.1

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 80.80.1.0/24	0.0.0.0	0	100	32768	?
* i	5.5.5.5	0	100	0	?
* i	2.2.2.2	0	100	0	?
*> 90.90.1.0/24	0.0.0.0	0	100	32768	?
* i	5.5.5.5	0	100	0	?
* i	2.2.2.2	0	100	0	?

Total number of prefixes 2

MH-2#

MH-2#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
 (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

```

Code      FEC      FTN-ID      Nhlfe-ID      Tunnel-id      Pri      LSP-Type      Out-Label
Out-Intf      ELC      Nexthop
  L>    2.2.2.2/32      1      3
xe10      No      20.20.20.2      2      -      Yes      LSP_DEFAULT      25601
  L>    4.4.4.4/32      2      6
xe10      No      20.20.20.2      5      -      Yes      LSP_DEFAULT      3
  L>    5.5.5.5/32      5      8
xe10      No      20.20.20.2      7      -      Yes      LSP_DEFAULT      25602
  L>    10.10.10.0/24      3      6
xe10      No      20.20.20.2      5      -      Yes      LSP_DEFAULT      3
  L>    30.30.30.0/24      4      6
xe10      No      20.20.20.2      5      -      Yes      LSP_DEFAULT      3

```

MH-2#

MH-2#sh ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
5.5.5.5	xe10	Passive	OPERATIONAL	30	01:15:31
4.4.4.4	xe10	Passive	OPERATIONAL	30	01:17:16

MH-2#

MH-2#sh ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
4.4.4.4	1	Full/DR	00:00:33	20.20.20.2	xe10	0

MH-2#

MH-2#sh nvo vxlan l3vni-map

L3VNI	L2VNI	IRB-interface
10000	100	irb100
10000	200	irb200

MH-2#

SH:

SH#sh evpn mpls

EVPN-MPLS Information

=====

Codes: NW - Network Port
 AC - Access Port
 (u) - Untagged

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-
Status	Src-Addr			Dst-Addr			

100	----	L2	NW	----	----	----	-
---	5.5.5.5		2.2.2.2				
100	----	L2	NW	----	----	----	-
---	5.5.5.5		3.3.3.3				
100	----	--	AC	sa9000.100	---	Single Homed Port	---
---	----		----				
200	----	L2	NW	----	----	----	-
---	5.5.5.5		2.2.2.2				
200	----	L2	NW	----	----	----	-
---	5.5.5.5		3.3.3.3				
200	----	--	AC	sa9000.200	---	Single Homed Port	---
---	----		----				
10000	----	L3	NW	----	----	----	-
---	5.5.5.5		2.2.2.2				
10000	----	L3	NW	----	----	----	-
---	5.5.5.5		3.3.3.3				

Total number of entries are 8

SH#

SH#sh evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
5.5.5.5	2.2.2.2	Installed	01:15:49	01:15:49	200
5.5.5.5	2.2.2.2	Installed	01:15:49	01:15:49	100
5.5.5.5	2.2.2.2	Installed	01:25:33	01:25:33	10000
5.5.5.5	3.3.3.3	Installed	01:15:49	01:15:49	200
5.5.5.5	3.3.3.3	Installed	01:15:49	01:15:49	100
5.5.5.5	3.3.3.3	Installed	01:25:33	01:25:33	10000

Total number of entries are 6

SH#

SH#sh evpn mpls mac-table

EVPN MPLS MAC Entries					
VNID	Interface	VlanId	In-VlanId	Mac-Addr	VTEP-Ip/ESI
Status	MAC move	AccessPort	Desc		Type
100	Static Remote	-----	0	0011.2233.4455	2.2.2.2
100	Static Local	-----	0	9819.2c86.3e01	5.5.5.5
100	Dynamic Remote	-----	0	0010.9400.0001	00:00:00:11:11:aa:aa:00:00:00
100	Dynamic Local	-----	0	0010.9400.0004	5.5.5.5
200	Static Remote	-----	0	0011.2233.4455	2.2.2.2

```

200      irb200      ----      ----      9819.2c86.3e01 5.5.5.5
Static Local      ----      0      ----
200      ----      ----      ----      0010.9400.0002 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote      ----      0      ----
200      sa9000.200 ----      ----      0010.9400.0005 5.5.5.5
Dynamic Local      ----      0      ----

```

Total number of entries are : 8

SH#

SH#sh evpn mpls arp-cache

MPLS-EVPN ARP-CACHE Information

=====

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
100	80.80.1.1	0011.2233.4455	Static Remote	----	
100	80.80.1.2	0010.9400.0001	Dynamic Remote	----	
100	80.80.1.3	9819.2c86.3e01	Static Local	----	
100	80.80.1.4	0010.9400.0004	Dynamic Local	----	
200	90.90.1.1	0011.2233.4455	Static Remote	----	
200	90.90.1.2	0010.9400.0002	Dynamic Remote	----	
200	90.90.1.3	9819.2c86.3e01	Static Local	----	
200	90.90.1.4	0010.9400.0005	Dynamic Local	----	

Total number of entries are 8

SH#

SH#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:64512]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	2.2.2.2	MPLS

RD[3.3.3.3:64512]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	3.3.3.3	MPLS

RD[5.5.5.5:100] VRF[red]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	3.3.3.3	MPLS
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	2.2.2.2	MPLS

RD[5.5.5.5:200] VRF[blue]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	3.3.3.3	MPLS
00:00:00:11:11:aa:aa:00:00:00	4294967295	19	2.2.2.2	MPLS

SH#

SH#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	2.2.2.2	MPLS

```
RD[2.2.2.2:200]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap
00:00:00:11:11:aa:aa:00:00:00  200      18          2.2.2.2     MPLS

RD[3.3.3.3:100]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap
00:00:00:11:11:aa:aa:00:00:00  100      17          3.3.3.3     MPLS

RD[3.3.3.3:200]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap
00:00:00:11:11:aa:aa:00:00:00  200      18          3.3.3.3     MPLS

RD[5.5.5.5:100] VRF[red]:
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap
00:00:00:11:11:aa:aa:00:00:00  100      17          3.3.3.3     MPLS
00:00:00:11:11:aa:aa:00:00:00  100      17          2.2.2.2     MPLS

RD[5.5.5.5:200] VRF[blue]:
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap
00:00:00:11:11:aa:aa:00:00:00  200      18          3.3.3.3     MPLS
00:00:00:11:11:aa:aa:00:00:00  200      18          2.2.2.2     MPLS
SH#
SH#sh evpn mpls label esi
S - Self
R - Remote
ESI                               PE-IP-ADDRESS  ESI-LABEL
=====
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2 (R)    19
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3 (R)    19
SH#
SH#sh evpn mpls label alias
S - Self
R - Remote
ESI                               PE-IP-ADDRESS  TENANT  ALIAS-LABEL
=====
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2 (R)    100     17
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2 (R)    200     18
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3 (R)    100     17
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3 (R)    200     18
SH#
SH#sh bgp l2vpn evpn
BGP table version is 6, local router ID is 5.5.5.5
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
                l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
```

- 3 - Inclusive Multicast Route
- 4 - Ethernet Segment Route
- 5 - Prefix Route

Network Encap	Next Hop	Metric	LocPrf	Weight	Path	Peer
RD[10:200]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	2.2.2.2	0	100	0	?	2.2.2.2 MPLS
*>i [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]	2.2.2.2	0	100	0	?	2.2.2.2 MPLS
RD[20:200]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	3.3.3.3	0	100	0	?	3.3.3.3 MPLS
*>i [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]	3.3.3.3	0	100	0	?	3.3.3.3 MPLS
RD[2.2.2.2:100]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
*>i [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
*>i [3]:[100]:[32,2.2.2.2]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
RD[2.2.2.2:200]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
*>i [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
*>i [3]:[200]:[32,2.2.2.2]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
RD[2.2.2.2:64512]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
*>i [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
RD[3.3.3.3:100]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]						

```

3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [3]:[100]:[32,3.3.3.3]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [3]:[200]:[32,3.3.3.3]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[5.5.5.5:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
5.5.5.5          0          100          32768 i  -----          MPLS
*>  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
5.5.5.5          0          100          32768 i  -----          MPLS
* i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
5.5.5.5          0          100          32768 i  -----          MPLS
* i  [3]:[100]:[32,2.2.2.2]
2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [3]:[100]:[32,3.3.3.3]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>  [3]:[100]:[32,5.5.5.5]
5.5.5.5          0          100          32768 i  -----          MPLS

RD[5.5.5.5:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS

```

```
* i          2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
          3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i          2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
          2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
          2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
          5.5.5.5          0          100          32768  i  -----          MPLS
*>  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
          5.5.5.5          0          100          32768  i  -----          MPLS
* i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
          3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i          2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
          5.5.5.5          0          100          32768  i  -----          MPLS
* i  [3]:[200]:[32,2.2.2.2]
          2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [3]:[200]:[32,3.3.3.3]
          3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>  [3]:[200]:[32,5.5.5.5]
          5.5.5.5          0          100          32768  i  -----          MPLS
```

Total number of prefixes 46

SH#

SH#sh bgp l2vpn evpn prefix-route

RD[10:200]

ESI	Eth-Tag	Prefix-Length	IP-Address	GW-IPAddress	L3VNID/LABEL
Nexthop	Encap	Router-Mac			
0	0	24	80.80.1.0	0.0.0.0	16
2.2.2.2	MPLS	e8c5:7a88:1738			
0	0	24	90.90.1.0	0.0.0.0	16
2.2.2.2	MPLS	e8c5:7a88:1738			

RD[20:200]

ESI	Eth-Tag	Prefix-Length	IP-Address	GW-IPAddress	L3VNID/LABEL
Nexthop	Encap	Router-Mac			
0	0	24	80.80.1.0	0.0.0.0	16
3.3.3.3	MPLS	e8c5:7ad2:5d98			
0	0	24	90.90.1.0	0.0.0.0	16
3.3.3.3	MPLS	e8c5:7ad2:5d98			

SH#

SH#sh bgp l2vpn evpn summary

BGP router identifier 5.5.5.5, local AS number 65010

BGP table version is 6

1 BGP AS-PATH entries

0 BGP community entries

Neighbor	AD	MACIP	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
PfxRcd			MCAST		ESI	PREFIX-ROUTE					


```

2.2.2.2      4 65010 198      189      5      0      0 01:15:56
14      3      6      2      1      2
3.3.3.3      4 65010 203      191      5      0      0 01:15:55
10      3      2      2      1      2

```

Total number of neighbors 2

Total number of Established sessions 2

SH#

SH#sh ip bgp vrf evpn_anycast

BGP table version is 1, local router ID is 90.90.1.3

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

	Network	Next Hop	Metric	LocPrf	Weight	Path
*>	80.80.1.0/24	0.0.0.0	0	100	32768	?
* i		3.3.3.3	0	100	0	?
* i		2.2.2.2	0	100	0	?
*>	90.90.1.0/24	0.0.0.0	0	100	32768	?
* i		3.3.3.3	0	100	0	?
* i		2.2.2.2	0	100	0	?

Total number of prefixes 2

SH#

SH#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

(m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	3				
			2	-	Yes	LSP_DEFAULT	25604
xe6	No	30.30.30.2					
L>	3.3.3.3/32	2	6				
			5	-	Yes	LSP_DEFAULT	25605
xe6	No	30.30.30.2					
L>	4.4.4.4/32	3	9				
			8	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					
L>	10.10.10.0/24	4	9				
			8	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					
L>	20.20.20.0/24	5	9				
			8	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					

SH#

SH#sh ldp session

```

Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
2.2.2.2              xe6        Active     OPERATIONAL 30         01:15:46
3.3.3.3              xe6        Active     OPERATIONAL 30         01:15:44
4.4.4.4              xe6        Active     OPERATIONAL 30         01:15:51

```

SH#

SH#sh ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

```

Neighbor ID      Pri   State             Dead Time   Address      Interface
Instance ID
4.4.4.4          1     Full/DR           00:00:33    30.30.30.2   xe6          0

```

SH#

SH#sh nvo vxlan l3vni-map

```

L3VNI      L2VNI      IRB-interface
=====
10000      100        irb100
10000      200        irb200

```

SH#

P1:

P1#sh ldp session

```

Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
3.3.3.3              xe1        Active     OPERATIONAL 30         01:21:33
2.2.2.2              xe4.1      Active     OPERATIONAL 30         01:21:35
5.5.5.5              xe6        Passive    OPERATIONAL 30         01:19:55

```

P1#

P1#sh ip ospf neighbor

Total number of full neighbors: 3

OSPF process 100 VRF(default):

```

Neighbor ID      Pri   State             Dead Time   Address      Interface
Instance ID
2.2.2.2          1     Full/Backup       00:00:37    10.10.10.1   xe4.1
0
3.3.3.3          1     Full/Backup       00:00:35    20.20.20.1   xe1          0
5.5.5.5          1     Full/Backup       00:00:35    30.30.30.1   xe6          0

```

P1#

P1#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport, (e) - FTN is ECMP

```

Code   FEC          FTN-ID   Nhlfe-ID  Tunnel-id  Pri   LSP-Type   Out-Label
Out-Intf  ELC    Nexthop
L>    2.2.2.2/32      1         2

```

xe4.1	No	10.10.10.1	1	-	Yes	LSP_DEFAULT	3
L>	3.3.3.3/32	2	4				
xe1	No	20.20.20.1	3	-	Yes	LSP_DEFAULT	3
L>	5.5.5.5/32	3	8				
xe6	No	30.30.30.1	7	-	Yes	LSP_DEFAULT	3
P1#							

EVPN MPLS IRB Asymmetric Centralized mode

Topology

[Figure 2-5](#) depicts the EVPN MPLS IRB Asymmetric centralized mode.

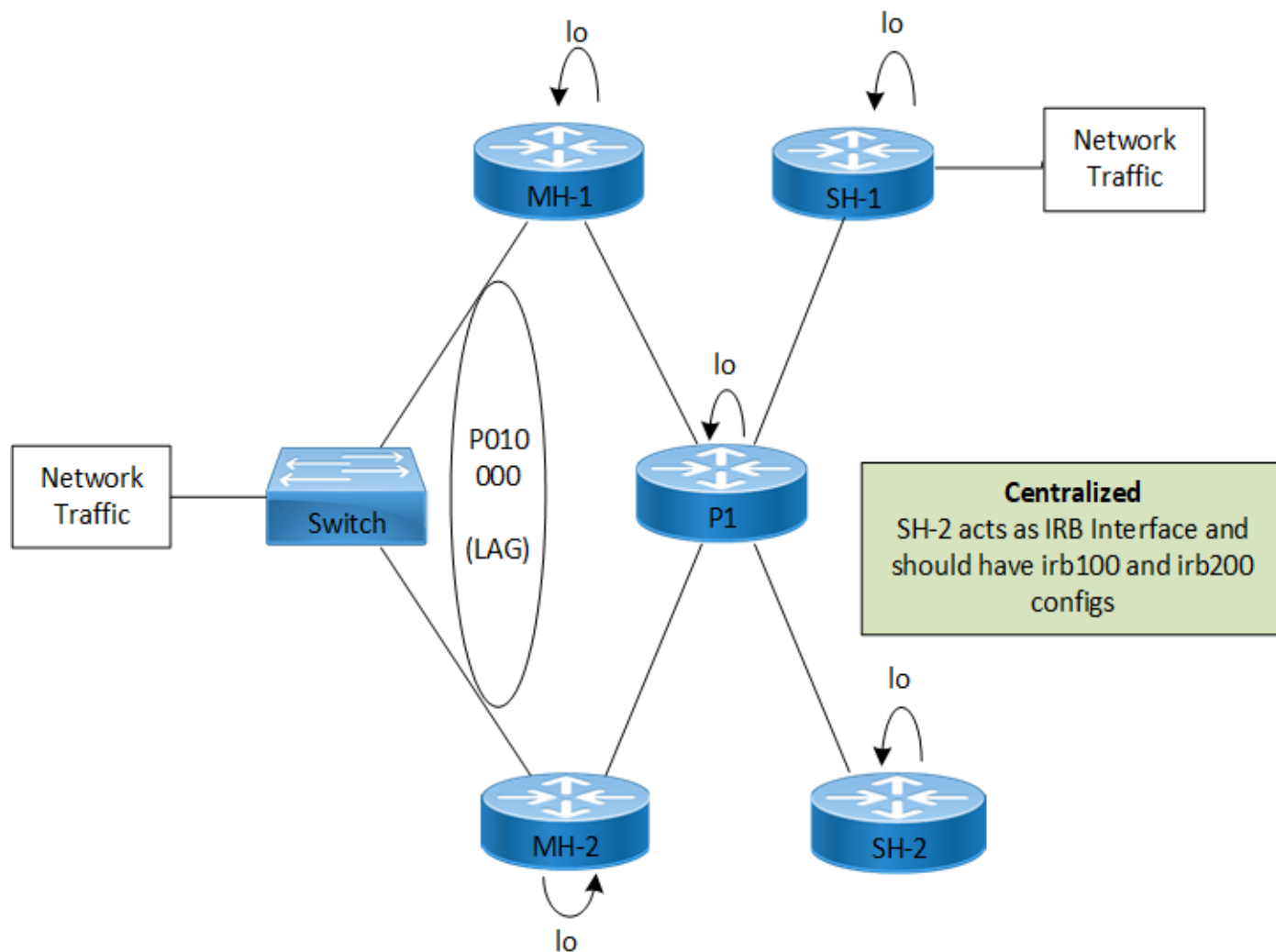


Figure 2-5: EVPN MPLS IRB Centralized Mode

Configurations:

SH-2:

Enable EVPN MPLS and IRB:

#configure terminal	Enter configuration mode.
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally

Loopback Interface:

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 6.6.6.6/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF:

(config)#mac vrf red	Create MAC VRF red.
(config-vrf)# rd 6.6.6.6:100	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode
(config)#mac vrf blue	Create MAC VRF blue.
(config-vrf)# rd 6.6.6.6:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF:

(config)#ip vrf evpn_anycast	Configure IP VRF evpn.
(config-vrf)# rd 30:200	Configure route distinguisher
(config-vrf)# route-target both 100:200	Configure route target
(config-vrf)# l3vni 10000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configuring IRB interface:

(config)#evpn irb-forwarding anycast-gateway- mac 0077.8899.5566	Configure anycast gateway MAC globally
(config)#interface irb100	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding evpn_anycast	Map L3 VRF to the IRB interface
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)# ip address 80.80.1.3/24 anycast	Assign IP address
(config-irb-if)#exit	Exit interface mode

(config)#interface irb200	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding evpn_anycast	Map L3 VRF to the IRB interface
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)# ip address 90.90.1.3/24 anycast	Assign IP address
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID:

(config)#evpn mpls vtep-ip-global 6.6.6.6	Configure VTEP global IP
(config)#evpn mpls id 100	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachability-protocol evpn-bgp red	Map the MAC VRF red
(config-evpn-mpls)# evpn irb irb100	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode
(config)#evpn mpls id 200	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachability-protocol evpn-bgp blue	Map the MAC VRF blue
(config-evpn-mpls)# evpn irb irb200	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 6.6.6.6	Enter LDP router-id
(config-router)# transport-address ipv4 6.6.6.6	Configure LDP transport address
(config-router)# targeted-peer ipv4 2.2.2.2	Configure LDP target peer address (MH-1)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 3.3.3.3	Configure LDP target peer address (MH-2)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 5.5.5.5	Configure LDP target peer address (SH-1)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side:

(config-if)#interface xe14	Enter interface mode
(config-if)# description connected to P1	Configure interface description
(config-if)# ip address 40.40.40.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#ospf router-id 6.6.6.6	Configure OSPF router id
(config-router)# network 6.6.6.6/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 40.40.40.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit OSPF mode

BGP Configuration:

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring MH-1 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 3.3.3.3 remote-as 65010	Configuring MH-2 as I-BGP neighbor using it's loopback IP

(config-router)# neighbor 3.3.3.3 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 5.5.5.5 remote-as 65010	Configuring MH-1 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 2.2.2.2 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 3.3.3.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 5.5.5.5 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf evpn_anycast	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

SH-1:**Enable EVPN MPLS and IRB:**

#configure terminal	Enter configuration mode.
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally

Loopback Interface:

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 5.5.5.5/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF:

(config)#mac vrf red	Create MAC VRF red.
(config-vrf)# rd 5.5.5.5:100	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode
(config)#mac vrf blue	Create MAC VRF blue.
(config-vrf)# rd 5.5.5.5:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Creating EVPN MPLS ID:

(config)#evpn mpls vtep-ip-global 5.5.5.5	Configure VTEP global IP
(config)#evpn mpls id 100	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachability-protocol evpn-bgp red	Map the MAC VRF red
(config-evpn-mpls)# evpn irb irb100	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode
(config)#evpn mpls id 200	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachability-protocol evpn-bgp blue	Map the MAC VRF blue
(config-evpn-mpls)# evpn irb irb200	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 5.5.5.5	Enter LDP router-id
(config-router)# transport-address ipv4 5.5.5.5	Configure LDP transport address
(config-router)# targeted-peer ipv4 2.2.2.2	Configure LDP target peer address (MH-1)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 3.3.3.3	Configure LDP target peer address (MH-2)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 6.6.6.6	Configure LDP target peer address (SH-2)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side:

(config-if)#interface xe6	Enter interface mode
(config-if)# description connected to P1	Configure interface description
(config-if)# ip address 30.30.30.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#ospf router-id 5.5.5.5	Configure OSPF router id
(config-router)# network 5.5.5.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit OSPF mode

BGP Configuration:

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring MH-1 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 3.3.3.3 remote-as 65010	Configuring MH-2 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 3.3.3.3 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 6.6.6.6 remote-as 65010	Configuring MH-2 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 6.6.6.6 update-source lo	Source of routing updates as loopback
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 2.2.2.2 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 3.3.3.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 6.6.6.6 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration:

(config-if)#interface sa9000	Creating Static LAG interface
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)#exit	Exiting out of interface mode
(config-if)#interface sa9000.100 switchport	Creating Static LAG L2 sub interface of physical interface xe12
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)#map vpn-id 100	Map VPN-ID 100
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config-if)#interface sa9000.200 switchport	Creating Static LAG L2 sub interface of physical interface xe12
(config-if)# encapsulation dot1q 200	Setting Encapsulation to dot1q with VLAN ID 200
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)#map vpn-id 200	Map VPN-ID 200
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config-if)#interface xe12	Enter the Interface mode

(config-if)# static-channel-group 9000	Map the physical interface xe12 as static LAG member
(config-if)#exit	Exit interface mode

P1:**Loopback Interface:**

#configure terminal	Enter configuration mode.
(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 4.4.4.4/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)# router-id 4.4.4.4	Configure router id
(config-router)# transport-address ipv4 4.4.4.4	Configure transport address
(config-router)#exit	Exit from LDP mode

Interface Configuration:

(config-if)#interface xe4	Enter the Interface mode for xe4.
(config-if)# mtu 9216	Configure MTU.
(config-if)#exit	Enable LDP on the physical interface
(config)#interface xe4.1	Create sub-interface xe4.1.
(config-if)# description connected-to-MH-1	Configure Interface description
(config-if)# ip address 10.10.10.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# encapsulation dot1q 20	Configure encapsulation as dotq
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter into Interface mode
(config-if)# description connected to MH-2	Configure Interface description
(config-if)# ip address 20.20.20.2/24	Configure IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe6	Enter into Interface mode
(config-if)# description connected to SH-1	Configure Interface description
(config-if)# ip address 30.30.30.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync

(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe10	Enter into Interface mode
(config-if)# description connected to SH-2	Configure Interface description
(config-if)# ip address 40.40.40.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSFP Configuration

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 4.4.4.4	Setting the Router ID as Loopback IP
(config-router)# network 4.4.4.4/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.10.10.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)# network 20.20.20.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)# network 40.40.40.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

MH-1:

Enable EVPN MPLS and IRB:

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mpls-mh enable	Configure hardware profile to enable EVPN MPLS multi homing in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface:

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 2.2.2.2/32 secondaryss	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF:

(config)#mac vrf red	Create MAC VRF red.
(config-vrf)# rd 2.2.2.2:100	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode
(config)#mac vrf blue	Create MAC VRF blue.
(config-vrf)# rd 2.2.2.2:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure Anycast Gateway MAC:

(config)#evpn irb-forwarding anycast-gateway- mac 0011.2233.4455	Configure anycast gateway MAC globally
--	--

Creating EVPN MPLS ID:

(config)#evpn mpls vtep-ip-global 2.2.2.2	Configure VTEP global IP
(config)#evpn mpls id 100	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp red	Map the MAC VRF red
(config-evpn-mpls)# evpn irb irb100	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode
(config)#evpn mpls id 200	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp blue	Map the MAC VRF blue
(config-evpn-mpls)# evpn irb irb200	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 2.2.2.2	Enter LDP router-id
(config-router)# transport-address ipv4 2.2.2.2	Configure LDP transport address
(config-router)# targeted-peer ipv4 5.5.5.5	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 6.6.6.6	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side:

(config-if)#interface xe0	Enter the Interface mode for xe0.
(config-if)# mtu 9216	Configure MTU.
(config-if)#exit	Exit from interface xe0
(config)#interface xe0.1	Create subinterface in xe10
(config-if)# encapsulation dot1q 20	Configure encapsulation as dotq
(config-if)# ip address 10.10.10.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 2.2.2.2	Router-ID configurations
(config-router)# network 2.2.2.2/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.10.10.0/24 area 0.0.0.0	Advertise network address in OSPF.

BGP Configuration:

(config-router)#router bgp 65010	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 3.3.3.3 remote-as 65010	Configuring MH-2 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 3.3.3.3 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 5.5.5.5 remote-as 65010	Configuring SH-1 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 6.6.6.6 remote-as 65010	Configuring SH-2 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 6.6.6.6 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 3.3.3.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 5.5.5.5 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 6.6.6.6 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf evpn	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration:

(config)#interface xe9	Enter configuration mode
(config-if)# mtu 9216	Configure MTU
(config-if)# channel-group 10000 mode active	Configure physical interface xe9 as LAG member po10000
(config-if)#exit	Exit from interface xe9
(config)#interface po10000	Create LAG interface po10000
(config-if)# mtu 9216	Configure MTU
(config-if)# description connected to Switch	Configure Interface description
(config-if)# evpn multi-homed system-mac 0000.1111.aaaa	Configure system MAC for multi homing
(config)#interface po10000.100 switchport	Creating L2 sub interface of physical interface xe9
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 100	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config)#interface po10000.200 switchport	Creating L2 sub interface of physical interface xe9
(config-if)# encapsulation dot1q 200	Setting Encapsulation to dot1q with VLAN ID 200
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 200	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode

MH-2:**Enable EVPN MPLS and IRB:**

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mpls-mh enable	Configure hardware profile to enable EVPN MPLS multi homing in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface:

(config-if)#interface lo	Enter the Interface mode for the loopback interface
(config-if)# ip address 3.3.3.3/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF:

(config)#mac vrf red	Create MAC VRF red.
(config-vrf)# rd 3.3.3.3:100	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode
(config)#mac vrf blue	Create MAC VRF blue.
(config-vrf)# rd 3.3.3.3:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure Anycast Gateway MAC:

(config)#evpn irb-forwarding anycastgateway-mac 0011.2233.4455	Configure anycast gateway MAC globally
--	--

Creating EVPN MPLS ID:

(config)#evpn mpls vtep-ip-global 3.3.3.3	Configure VTEP global IP
(config)#evpn mpls id 100	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp red	Map the MAC VRF red
(config-evpn-mpls)# evpn irb irb100	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode
(config)#evpn mpls id 200	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp blue	Map the MAC VRF blue
(config-evpn-mpls)# evpn irb irb200	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)# transport-address ipv4 3.3.3.3	Configure LDP transport address
(config-router)# targeted-peer ipv4 5.5.5.5	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 6.6.6.6	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side:

(config-if)#interface xe10	Enter the configuration mode.
(config-if)# description connected to P1	Configure Interface description
(config-if)# ip address 20.20.20.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 3.3.3.3	Router-ID configurations
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 20.20.20.0/24 area 0.0.0.0	Advertise network address in OSPF.

BGP Configuration:

(config-router)#router bgp 65010	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 5.5.5.5 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 6.6.6.6 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 6.6.6.6 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 2.2.2.2 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 5.5.5.5 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 6.6.6.6 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf evpn_anycast	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration:

(config)#interface xe21	Enter configuration mode
(config-if)# mtu 9216	Configure MTU
(config-if)# channel-group 10000 mode active	Configure physical interface xe21 as LAG member po10000
(config-if)#exit	Exit from interface xe21
(config)#interface po10000	Create LAG interface po10000
(config-if)# mtu 9216	Configure MTU
(config-if)# description connected to Switch	Configure Interface description
(config-if)# evpn multi-homed system-mac 0000.1111.aaaa	Configure system MAC for multi homing
(config)#interface po10000.100 switchport	Creating L2 sub interface of physical interface xe21
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100

(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 100	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config)#interface po10000.200 switchport	Creating L2 sub interface of physical interface xe21
(config-if)# encapsulation dot1q 200	Setting Encapsulation to dot1q with VLAN ID 200
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 200	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode

Validation

Note: Remote entries cannot be fetched from through MAC table/ARP cache/ND cache. However they can be fetched from the BGP table.

MH-1:

```
MH-1#sh evpn mpls
EVPN-MPLS Information
=====
```

```
Codes: NW - Network Port
       AC - Access Port
       (u) - Untagged
```

VPN-ID Status	EVI-Name Src-Addr	EVI-Type Type	Type Dst-Addr	Interface	ESI	VLAN	DF-
100 ---	---- 2.2.2.2	L2	NW 6.6.6.6	----	----	----	-
100 ---	---- 2.2.2.2	L2	NW 3.3.3.3	----	----	----	-
100 ---	---- 2.2.2.2	L2	NW 5.5.5.5	----	----	----	-
100 ---	---- --	AC	po10000.100	00:00:00:11:11:aa:aa:00:00:00	----	DF	
200 ---	---- 2.2.2.2	L2	NW 6.6.6.6	----	----	----	-
200 ---	---- 2.2.2.2	L2	NW 3.3.3.3	----	----	----	-
200 ---	---- 2.2.2.2	L2	NW 5.5.5.5	----	----	----	-

```

200      ----      --      AC  po10000.200 00:00:00:11:11:aa:aa:00:00:00 ----      DF
-----      ----

```

Total number of entries are 8

MH-1#

MH-1#sh evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
2.2.2.2	6.6.6.6	Installed	01:38:59	01:38:59	200
2.2.2.2	6.6.6.6	Installed	01:38:59	01:38:59	100
2.2.2.2	3.3.3.3	Installed	01:38:59	01:38:59	200
2.2.2.2	3.3.3.3	Installed	01:38:59	01:38:59	100
2.2.2.2	5.5.5.5	Installed	01:38:59	01:38:59	200
2.2.2.2	5.5.5.5	Installed	01:38:59	01:38:59	100

Total number of entries are 6

MH-1#

MH-1#sh evpn mpls mac-table

```

=====
=====
                                     EVPN MPLS MAC Entries
=====
=====
VNID      Interface VlanId  In-VlanId Mac-Addr      VTEP-Ip/ESI      Type
Status    MAC move AccessPortDesc
=====
100      ----      ----      ----      0077.8899.5566 6.6.6.6
Static Remote -----      0      -----
100      ----      ----      ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote -----      0      -----
200      ----      ----      ----      0077.8899.5566 6.6.6.6
Static Remote -----      0      -----
200      ----      ----      ----      0010.9400.0005 5.5.5.5
Dynamic Remote -----      0      -----

```

Total number of entries are : 4

MH-1#

MH-1#sh evpn mpls arp-cache

MPLS-EVPN ARP-CACHE Information

=====

ARP Timeout : 300 sec Random-Jitter-Max : 200

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
100	80.80.1.2	0010.9400.0001	Dynamic Remote	----	

```

100      80.80.1.3      0077.8899.5566 Static Remote ----
200      90.90.1.3      0077.8899.5566 Static Remote ----
200      90.90.1.4      0010.9400.0005 Dynamic Remote ----

```

Total number of entries are 4

MH-1#

MH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:100] VRF[red]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	16	3.3.3.3	MPLS

RD[2.2.2.2:200] VRF[blue]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	16	3.3.3.3	MPLS

RD[2.2.2.2:64512] VRF[evpn-gvrf-1]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	16	2.2.2.2	MPLS

RD[3.3.3.3:64512]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	16	3.3.3.3	MPLS

MH-1#

MH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100] VRF[red]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	2.2.2.2	MPLS
00:00:00:11:11:aa:aa:00:00:00	100	17	3.3.3.3	MPLS

RD[2.2.2.2:200] VRF[blue]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	2.2.2.2	MPLS
00:00:00:11:11:aa:aa:00:00:00	200	18	3.3.3.3	MPLS

RD[3.3.3.3:100]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	3.3.3.3	MPLS

RD[3.3.3.3:200]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	3.3.3.3	MPLS

MH-1#

MH-1#sh evpn mpls label esi

S - Self

R - Remote

ESI	PE-IP-ADDRESS	ESI-LABEL
-----	---------------	-----------


```
=====
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2 (S)          16
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3 (R)          16
MH-1#
```

MH-1#sh evpn mpls label alias

S - Self

R - Remote

ESI	PE-IP-ADDRESS	TENANT	ALIAS-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (S)	100	17
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (S)	200	18
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (R)	100	17
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (R)	200	18

MH-1#

MH-1#sh bgp l2vpn evpn

BGP table version is 3, local router ID is 2.2.2.2

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]

1 - Ethernet Auto-discovery Route

2 - MAC/IP Route

3 - Inclusive Multicast Route

4 - Ethernet Segment Route

5 - Prefix Route

Network Encap	Next Hop	Metric	LocPrf	Weight	Path	Peer
RD[30:200]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	6.6.6.6	0	100	0	? 6.6.6.6	MPLS
*>i [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]	6.6.6.6	0	100	0	? 6.6.6.6	MPLS

RD[2.2.2.2:100] VRF[red]:

*> [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]	2.2.2.2	0	100	32768	i -----	MPLS
* i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]	3.3.3.3	0	100	0	i 3.3.3.3	MPLS
* i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]	3.3.3.3	0	100	0	i 3.3.3.3	MPLS
* i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]	3.3.3.3	0	100	0	i 3.3.3.3	MPLS
* i [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]						

```

        6.6.6.6          0          100          0    i  6.6.6.6          MPLS
*>  [3]:[100]:[32,2.2.2.2]
        2.2.2.2          0          100          32768  i  -----          MPLS
* i  [3]:[100]:[32,3.3.3.3]
        3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [3]:[100]:[32,5.5.5.5]
        5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [3]:[100]:[32,6.6.6.6]
        6.6.6.6          0          100          0    i  6.6.6.6          MPLS

RD[2.2.2.2:200] VRF[blue]:
*>  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
        2.2.2.2          0          100          32768  i  -----          MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
        3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
        5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
        5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
        6.6.6.6          0          100          0    i  6.6.6.6          MPLS
*>  [3]:[200]:[32,2.2.2.2]
        2.2.2.2          0          100          32768  i  -----          MPLS
* i  [3]:[200]:[32,3.3.3.3]
        3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [3]:[200]:[32,5.5.5.5]
        5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [3]:[200]:[32,6.6.6.6]
        6.6.6.6          0          100          0    i  6.6.6.6          MPLS

RD[2.2.2.2:64512] VRF[evpn-gvrf-1]:
*>  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
        2.2.2.2          0          100          32768  i  -----          MPLS
*>  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
        2.2.2.2          0          100          32768  i  -----          MPLS
* i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
        3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
        3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
        3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
        3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [3]:[100]:[32,3.3.3.3]
        3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:200]

```

```
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
      3.3.3.3          0          100          0      i  3.3.3.3          MPLS
*>i  [3]:[200]:[32,3.3.3.3]
      3.3.3.3          0          100          0      i  3.3.3.3          MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
      3.3.3.3          0          100          0      i  3.3.3.3          MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
      3.3.3.3          0          100          0      i  3.3.3.3          MPLS

RD[5.5.5.5:100]
*>i  [3]:[100]:[32,5.5.5.5]
      5.5.5.5          0          100          0      i  5.5.5.5          MPLS

RD[5.5.5.5:200]
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
      5.5.5.5          0          100          0      i  5.5.5.5          MPLS
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
      5.5.5.5          0          100          0      i  5.5.5.5          MPLS
*>i  [3]:[200]:[32,5.5.5.5]
      5.5.5.5          0          100          0      i  5.5.5.5          MPLS

RD[6.6.6.6:100]
*>i  [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]
      6.6.6.6          0          100          0      i  6.6.6.6          MPLS
*>i  [3]:[100]:[32,6.6.6.6]
      6.6.6.6          0          100          0      i  6.6.6.6          MPLS

RD[6.6.6.6:200]
*>i  [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
      6.6.6.6          0          100          0      i  6.6.6.6          MPLS
*>i  [3]:[200]:[32,6.6.6.6]
      6.6.6.6          0          100          0      i  6.6.6.6          MPLS
```

Total number of prefixes 39

MH-1#

MH-1#sh bgp l2vpn evpn prefix-route

```
RD[30:200]
ESI          Eth-Tag Prefix-Length  IP-Address  GW-IPAddress  L3VNID/LABEL
Nexthop      Encap    Router-Mac
0            0        24        80.80.1.0    0.0.0.0       16
6.6.6.6      MPLS      e8c5:7aff:96de
0            0        24        90.90.1.0    0.0.0.0       16
6.6.6.6      MPLS      e8c5:7aff:96de
MH-1#
```

MH-1#sh bgp l2vpn evpn summary

BGP router identifier 2.2.2.2, local AS number 65010

BGP table version is 3
 1 BGP AS-PATH entries
 0 BGP community entries

Neighbor PfxRcd	AD	MACIP	V MCAST	AS	MsgRcv ESI	MsgSen PREFIX-ROUTE	TblVer	InQ	OutQ	Up/Down	State/
3.3.3.3			4	65010	244	241	2	0	0	01:39:10	
8	3	2	2	1	0						
5.5.5.5			4	65010	237	238	2	0	0	01:39:10	
4	0	2	2	0	0						
6.6.6.6			4	65010	239	240	2	0	0	01:39:10	
6	0	2	2	0	2						

Total number of neighbors 3

Total number of Established sessions 3
 MH-1#

MH-1#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
 (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	3.3.3.3/32	1	2				
xe0.1	No	10.10.10.2	1	-	Yes	LSP_DEFAULT	25605
L>	4.4.4.4/32	2	5				
xe0.1	No	10.10.10.2	4	-	Yes	LSP_DEFAULT	3
L>	5.5.5.5/32	3	7				
xe0.1	No	10.10.10.2	6	-	Yes	LSP_DEFAULT	25606
L>	6.6.6.6/32	4	10				
xe0.1	No	10.10.10.2	9	-	Yes	LSP_DEFAULT	25609
L>	20.20.20.0/24	5	5				
xe0.1	No	10.10.10.2	4	-	Yes	LSP_DEFAULT	3
L>	30.30.30.0/24	6	5				
xe0.1	No	10.10.10.2	4	-	Yes	LSP_DEFAULT	3
L>	40.40.40.0/24	7	5				
xe0.1	No	10.10.10.2	4	-	Yes	LSP_DEFAULT	3

MH-1#

MH-1#sh ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
5.5.5.5	xe0.1	Passive	OPERATIONAL	30	01:39:03

```
6.6.6.6          xe0.1      Passive  OPERATIONAL  30    01:39:03
4.4.4.4          xe0.1      Passive  OPERATIONAL  30    01:39:01
MH-1#
```

MH-1#sh ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
4.4.4.4	1	Full/DR	00:00:35	10.10.10.2	xe0.1	0

MH-1#

MH-2:

MH-2#sh evpn mpls

EVPN-MPLS Information

=====

Codes: NW - Network Port

AC - Access Port

(u) - Untagged

VPN-ID Status	EVI-Name Src-Addr	EVI-Type Type	Type	Interface	ESI	VLAN	DF-
100	----	L2	NW	----	----	----	-
---	3.3.3.3		5.5.5.5				
100	----	L2	NW	----	----	----	-
---	3.3.3.3		2.2.2.2				
100	----	L2	NW	----	----	----	-
---	3.3.3.3		6.6.6.6				
100	----	--	AC	po10000.100	00:00:00:11:11:aa:aa:00:00:00	----	
NON-DF	----	----					
200	----	L2	NW	----	----	----	-
---	3.3.3.3		5.5.5.5				
200	----	L2	NW	----	----	----	-
---	3.3.3.3		2.2.2.2				
200	----	L2	NW	----	----	----	-
---	3.3.3.3		6.6.6.6				
200	----	--	AC	po10000.200	00:00:00:11:11:aa:aa:00:00:00	----	
NON-DF	----	----					

Total number of entries are 8

MH-2#

MH-2#sh evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
3.3.3.3	5.5.5.5	Installed	01:52:28	01:52:28	200

3.3.3.3	5.5.5.5	Installed	01:52:28	01:52:28	100
3.3.3.3	2.2.2.2	Installed	01:41:32	01:41:32	200
3.3.3.3	2.2.2.2	Installed	01:41:32	01:41:32	100
3.3.3.3	6.6.6.6	Installed	01:52:28	01:52:28	200
3.3.3.3	6.6.6.6	Installed	01:52:28	01:52:28	100

Total number of entries are 6
MH-2#

MH-2#sh evpn mpls mac-table

```
=====
EVPN MPLS MAC Entries
=====
```

VNID	Interface	VlanId	In-VlanId	Mac-Addr	VTEP-Ip/ESI	Type
Status	MAC move	AccessPort	Desc			
100	Static Remote	-----	0	-----	0077.8899.5566 6.6.6.6	
100	Dynamic Local	po10000.100	-----	0	0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00	
200	Static Remote	-----	0	-----	0077.8899.5566 6.6.6.6	
200	Dynamic Remote	-----	0	-----	0010.9400.0005 5.5.5.5	

Total number of entries are : 4

MH-2#

MH-2#sh evpn mpls arp-cache

MPLS-EVPN ARP-CACHE Information

=====

ARP Timeout : 300 sec Random-Jitter-Max : 200

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
100	80.80.1.2	0010.9400.0001	Dynamic Local	249	2
100	80.80.1.3	0077.8899.5566	Static Remote	----	
200	90.90.1.3	0077.8899.5566	Static Remote	----	
200	90.90.1.4	0010.9400.0005	Dynamic Remote	----	

Total number of entries are 4

MH-2#

MH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:64512]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	16	2.2.2.2	MPLS

```
RD[3.3.3.3:100] VRF[red]:
ESI                      Eth-Tag    VNID/LABEL    Nexthop IP    Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16            2.2.2.2       MPLS
```

```
RD[3.3.3.3:200] VRF[blue]:
ESI                      Eth-Tag    VNID/LABEL    Nexthop IP    Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16            2.2.2.2       MPLS
```

```
RD[3.3.3.3:64512] VRF[evpn-gvrf-1]:
ESI                      Eth-Tag    VNID/LABEL    Nexthop IP    Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16            3.3.3.3       MPLS
```

MH-2#

MH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

```
RD[2.2.2.2:100]
ESI                      Eth-Tag    VNID/LABEL    Nexthop IP    Encap
00:00:00:11:11:aa:aa:00:00:00  100        17            2.2.2.2       MPLS
```

```
RD[2.2.2.2:200]
ESI                      Eth-Tag    VNID/LABEL    Nexthop IP    Encap
00:00:00:11:11:aa:aa:00:00:00  200        18            2.2.2.2       MPLS
```

```
RD[3.3.3.3:100] VRF[red]:
ESI                      Eth-Tag    VNID/LABEL    Nexthop IP    Encap
00:00:00:11:11:aa:aa:00:00:00  100        17            2.2.2.2       MPLS
00:00:00:11:11:aa:aa:00:00:00  100        17            3.3.3.3       MPLS
```

```
RD[3.3.3.3:200] VRF[blue]:
ESI                      Eth-Tag    VNID/LABEL    Nexthop IP    Encap
00:00:00:11:11:aa:aa:00:00:00  200        18            2.2.2.2       MPLS
00:00:00:11:11:aa:aa:00:00:00  200        18            3.3.3.3       MPLS
```

MH-2#

MH-2#sh evpn mpls label esi

S - Self

R - Remote

ESI	PE-IP-ADDRESS	ESI-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	16
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (S)	16

MH-2#

MH-2#sh evpn mpls label alias

S - Self

R - Remote

ESI	PE-IP-ADDRESS	TENANT	ALIAS-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	100	17

```
00:00:00:11:11:aa:aa:00:00:00 2.2.2.2(R) 200 18
00:00:00:11:11:aa:aa:00:00:00 3.3.3.3(S) 100 17
00:00:00:11:11:aa:aa:00:00:00 3.3.3.3(S) 200 18
MH-2#
```

MH-2#sh bgp l2vpn evpn

BGP table version is 7, local router ID is 3.3.3.3

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]

1 - Ethernet Auto-discovery Route

2 - MAC/IP Route

3 - Inclusive Multicast Route

4 - Ethernet Segment Route

5 - Prefix Route

Network Encap	Next Hop	Metric	LocPrf	Weight	Path	Peer
RD[30:200]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	6.6.6.6	0	100	0	? 6.6.6.6	MPLS
*>i [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]	6.6.6.6	0	100	0	? 6.6.6.6	MPLS
RD[2.2.2.2:100]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [3]:[100]:[32,2.2.2.2]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
RD[2.2.2.2:200]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [3]:[200]:[32,2.2.2.2]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
RD[2.2.2.2:64512]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>i [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
RD[3.3.3.3:100] VRF[red]:						
* i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]	2.2.2.2	0	100	0	i 2.2.2.2	MPLS
*>	3.3.3.3	0	100	32768	i -----	MPLS
* i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]						


```

                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                3.3.3.3          0          100          32768  i  -----          MPLS
*>  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                3.3.3.3          0          100          32768  i  -----          MPLS
* i  [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]
                6.6.6.6          0          100          0    i  6.6.6.6          MPLS
* i  [3]:[100]:[32,2.2.2.2]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>  [3]:[100]:[32,3.3.3.3]
                3.3.3.3          0          100          32768  i  -----          MPLS
* i  [3]:[100]:[32,5.5.5.5]
                5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [3]:[100]:[32,6.6.6.6]
                6.6.6.6          0          100          0    i  6.6.6.6          MPLS

RD[3.3.3.3:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                3.3.3.3          0          100          32768  i  -----          MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
                5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
                5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
                6.6.6.6          0          100          0    i  6.6.6.6          MPLS
* i  [3]:[200]:[32,2.2.2.2]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>  [3]:[200]:[32,3.3.3.3]
                3.3.3.3          0          100          32768  i  -----          MPLS
* i  [3]:[200]:[32,5.5.5.5]
                5.5.5.5          0          100          0    i  5.5.5.5          MPLS
* i  [3]:[200]:[32,6.6.6.6]
                6.6.6.6          0          100          0    i  6.6.6.6          MPLS

RD[3.3.3.3:64512] VRF[evpn-gvrf-1]:
*>  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                3.3.3.3          0          100          32768  i  -----          MPLS
* i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                3.3.3.3          0          100          32768  i  -----          MPLS

RD[5.5.5.5:100]
*>i  [3]:[100]:[32,5.5.5.5]
                5.5.5.5          0          100          0    i  5.5.5.5          MPLS

RD[5.5.5.5:200]

```

```
*>i [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
      5.5.5.5          0          100          0      i  5.5.5.5          MPLS
*>i [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
      5.5.5.5          0          100          0      i  5.5.5.5          MPLS
*>i [3]:[200]:[32,5.5.5.5]
      5.5.5.5          0          100          0      i  5.5.5.5          MPLS
```

RD[6.6.6.6:100]

```
*>i [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]
      6.6.6.6          0          100          0      i  6.6.6.6          MPLS
*>i [3]:[100]:[32,6.6.6.6]
      6.6.6.6          0          100          0      i  6.6.6.6          MPLS
```

RD[6.6.6.6:200]

```
*>i [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
      6.6.6.6          0          100          0      i  6.6.6.6          MPLS
*>i [3]:[200]:[32,6.6.6.6]
      6.6.6.6          0          100          0      i  6.6.6.6          MPLS
```

Total number of prefixes 37

MH-2#

MH-2#sh bgp l2vpn evpn prefix-route

RD[30:200]

ESI	Eth-Tag	Prefix-Length	IP-Address	GW-IPAddress	L3VNID/LABEL
Nexthop	Encap	Router-Mac			
0	0	24	80.80.1.0	0.0.0.0	16
6.6.6.6	MPLS	e8c5:7aff:96de			
0	0	24	90.90.1.0	0.0.0.0	16
6.6.6.6	MPLS	e8c5:7aff:96de			

MH-2#

MH-2#sh bgp l2vpn evpn summary

BGP router identifier 3.3.3.3, local AS number 65010

BGP table version is 7

1 BGP AS-PATH entries

0 BGP community entries

Neighbor	AD	MACIP	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
PfxRcd			MA	CAST	ESI	PREFIX-ROUTE					
2.2.2.2			4	65010	279	273	7	0	0	01:41:33	
6	3	0	2	1	0						
5.5.5.5			4	65010	270	276	7	0	0	01:52:30	
4	0	2	2	0	0						
6.6.6.6			4	65010	271	277	7	0	0	01:52:30	
6	0	2	2	0	2						

Total number of neighbors 3

Total number of Established sessions 3

MH-2#

```
MH-2#sh mpls forwarding-table
```

```
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
        (m) - FTN mapped over multipath transport, (e) - FTN is ECMP
```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	5	13				
			12	-	Yes	LSP_DEFAULT	25600
xe10	No	20.20.20.2					
L>	4.4.4.4/32	2	4				
			3	-	Yes	LSP_DEFAULT	3
xe10	No	20.20.20.2					
L>	5.5.5.5/32	3	6				
			5	-	Yes	LSP_DEFAULT	25610
xe10	No	20.20.20.2					
L>	6.6.6.6/32	4	8				
			7	-	Yes	LSP_DEFAULT	25611
xe10	No	20.20.20.2					
L>	10.10.10.0/24	1	4				
			3	-	Yes	LSP_DEFAULT	3
xe10	No	20.20.20.2					
L>	30.30.30.0/24	6	4				
			3	-	Yes	LSP_DEFAULT	3
xe10	No	20.20.20.2					
L>	40.40.40.0/24	7	4				
			3	-	Yes	LSP_DEFAULT	3
xe10	No	20.20.20.2					

```
MH-2#
```

```
MH-2#sh ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
4.4.4.4	xe10	Passive	OPERATIONAL	30	01:52:33
5.5.5.5	xe10	Passive	OPERATIONAL	30	01:52:10
6.6.6.6	xe10	Passive	OPERATIONAL	30	01:52:10

```
MH-2#
```

```
MH-2#sh ip ospf neighbor
```

```
Total number of full neighbors: 1
```

```
OSPF process 100 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	
4.4.4.4	1	Full/DR	00:00:31	20.20.20.2	xe10	0

```
MH-2#
```

SH-1:

```
SH-1#sh evpn mpls
```

EVPN-MPLS Information

=====

Codes: NW - Network Port
AC - Access Port
(u) - Untagged

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-
Status	Src-Addr		Dst-Addr				
100	----	L2	NW	----	----	----	-
---	5.5.5.5		6.6.6.6				
100	----	L2	NW	----	----	----	-
---	5.5.5.5		2.2.2.2				
100	----	L2	NW	----	----	----	-
---	5.5.5.5		3.3.3.3				
100	----	--	AC	sa9000.100	--- Single Homed Port ---	----	-
---	----		----				
200	----	L2	NW	----	----	----	-
---	5.5.5.5		6.6.6.6				
200	----	L2	NW	----	----	----	-
---	5.5.5.5		2.2.2.2				
200	----	L2	NW	----	----	----	-
---	5.5.5.5		3.3.3.3				
200	----	--	AC	sa9000.200	--- Single Homed Port ---	----	-
---	----		----				

Total number of entries are 8

SH-1#

```
SH-1#sh evpn mpls tunnel
```

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
5.5.5.5	6.6.6.6	Installed	01:57:20	01:57:20	200
5.5.5.5	6.6.6.6	Installed	01:57:20	01:57:20	100
5.5.5.5	2.2.2.2	Installed	01:44:57	01:44:57	200
5.5.5.5	2.2.2.2	Installed	01:44:57	01:44:57	100
5.5.5.5	3.3.3.3	Installed	01:55:53	01:55:53	200
5.5.5.5	3.3.3.3	Installed	01:55:53	01:55:53	100

Total number of entries are 6

SH-1#

```
SH-1#sh evpn mpls mac-table
```

=====

EVPN MPLS MAC Entries

=====

VNID	Interface	VlanId	In-VlanId	Mac-Addr	VTEP-IP/ESI	Type
Status	MAC move	AccessPort	Desc			
<hr/>						

```

100      ----      ----      ----      0077.8899.5566 6.6.6.6
Static Remote ----- 0      -----
100      ----      ----      ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote ----- 0      -----
200      ----      ----      ----      0077.8899.5566 6.6.6.6
Static Remote ----- 0      -----
200      sa9000.200 ----      ----      0010.9400.0005 5.5.5.5
Dynamic Local ----- 0      -----

```

Total number of entries are : 4

SH-1#

```

SH-1#sh evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
=====

```

ARP Timeout : 300 sec Random-Jitter-Max : 200

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
100	80.80.1.2	0010.9400.0001	Dynamic Remote	----	
100	80.80.1.3	0077.8899.5566	Static Remote	----	
200	90.90.1.3	0077.8899.5566	Static Remote	----	
200	90.90.1.4	0010.9400.0005	Dynamic Local	443	2

Total number of entries are 4

SH-1#

SH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-es

```

RD[2.2.2.2:64512]
ESI                               Eth-Tag    VNID/LABEL    Nexthop IP    Encap
00:00:00:11:11:aa:aa:00:00:00    4294967295 16             2.2.2.2       MPLS

RD[3.3.3.3:64512]
ESI                               Eth-Tag    VNID/LABEL    Nexthop IP    Encap
00:00:00:11:11:aa:aa:00:00:00    4294967295 16             3.3.3.3       MPLS

RD[5.5.5.5:100] VRF[red]:
ESI                               Eth-Tag    VNID/LABEL    Nexthop IP    Encap
00:00:00:11:11:aa:aa:00:00:00    4294967295 16             2.2.2.2       MPLS
00:00:00:11:11:aa:aa:00:00:00    4294967295 16             3.3.3.3       MPLS

RD[5.5.5.5:200] VRF[blue]:
ESI                               Eth-Tag    VNID/LABEL    Nexthop IP    Encap
00:00:00:11:11:aa:aa:00:00:00    4294967295 16             2.2.2.2       MPLS
00:00:00:11:11:aa:aa:00:00:00    4294967295 16             3.3.3.3       MPLS
SH-1#

```

SH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	2.2.2.2	MPLS

RD[2.2.2.2:200]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	2.2.2.2	MPLS

RD[3.3.3.3:100]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	3.3.3.3	MPLS

RD[3.3.3.3:200]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	3.3.3.3	MPLS

RD[5.5.5.5:100] VRF[red]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	2.2.2.2	MPLS
00:00:00:11:11:aa:aa:00:00:00	100	17	3.3.3.3	MPLS

RD[5.5.5.5:200] VRF[blue]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	2.2.2.2	MPLS
00:00:00:11:11:aa:aa:00:00:00	200	18	3.3.3.3	MPLS

SH-1#

SH-1#sh evpn mpls label esi

S - Self

R - Remote

ESI	PE-IP-ADDRESS	ESI-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	16
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (R)	16

SH-1#

SH-1#sh evpn mpls label alias

S - Self

R - Remote

ESI	PE-IP-ADDRESS	TENANT	ALIAS-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	100	17
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	200	18
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (R)	100	17
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (R)	200	18

SH-1#

SH-1#sh bgp l2vpn evpn

BGP table version is 10, local router ID is 5.5.5.5

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

1 - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]

1 - Ethernet Auto-discovery Route

2 - MAC/IP Route

3 - Inclusive Multicast Route

4 - Ethernet Segment Route

5 - Prefix Route

Network Encap	Next Hop	Metric	LocPrf	Weight	Path	Peer
RD[30:200]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	6.6.6.6	0	100	0	?	6.6.6.6 MPLS
*>i [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]	6.6.6.6	0	100	0	?	6.6.6.6 MPLS
RD[2.2.2.2:100]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
*>i [3]:[100]:[32,2.2.2.2]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
RD[2.2.2.2:200]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
*>i [3]:[200]:[32,2.2.2.2]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
RD[2.2.2.2:64512]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
*>i [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]	2.2.2.2	0	100	0	i	2.2.2.2 MPLS
RD[3.3.3.3:100]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]	3.3.3.3	0	100	0	i	3.3.3.3 MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]	3.3.3.3	0	100	0	i	3.3.3.3 MPLS
*>i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]	3.3.3.3	0	100	0	i	3.3.3.3 MPLS
*>i [3]:[100]:[32,3.3.3.3]	3.3.3.3	0	100	0	i	3.3.3.3 MPLS
RD[3.3.3.3:200]						
*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]	3.3.3.3	0	100	0	i	3.3.3.3 MPLS
*>i [3]:[200]:[32,3.3.3.3]						

```

3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[5.5.5.5:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]
6.6.6.6          0          100          0    i  6.6.6.6          MPLS
* i  [3]:[100]:[32,2.2.2.2]
2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [3]:[100]:[32,3.3.3.3]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>  [3]:[100]:[32,5.5.5.5]
5.5.5.5          0          100          32768 i  -----          MPLS
* i  [3]:[100]:[32,6.6.6.6]
6.6.6.6          0          100          0    i  6.6.6.6          MPLS

RD[5.5.5.5:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  3.3.3.3          0          100          0    i  3.3.3.3          MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
5.5.5.5          0          100          32768 i  -----          MPLS
*>  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
5.5.5.5          0          100          32768 i  -----          MPLS
* i  [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
6.6.6.6          0          100          0    i  6.6.6.6          MPLS
* i  [3]:[200]:[32,2.2.2.2]
2.2.2.2          0          100          0    i  2.2.2.2          MPLS
* i  [3]:[200]:[32,3.3.3.3]
3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>  [3]:[200]:[32,5.5.5.5]
5.5.5.5          0          100          32768 i  -----          MPLS
* i  [3]:[200]:[32,6.6.6.6]

```



```

6.6.6.6          0          100          0    i  6.6.6.6          MPLS

RD[6.6.6.6:100]
*>i  [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]
6.6.6.6          0          100          0    i  6.6.6.6          MPLS
*>i  [3]:[100]:[32,6.6.6.6]
6.6.6.6          0          100          0    i  6.6.6.6          MPLS

RD[6.6.6.6:200]
*>i  [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
6.6.6.6          0          100          0    i  6.6.6.6          MPLS
*>i  [3]:[200]:[32,6.6.6.6]
6.6.6.6          0          100          0    i  6.6.6.6          MPLS

Total number of prefixes 38
SH-1#

SH-1#sh bgp l2vpn evpn prefix-route

RD[30:200]
ESI      Eth-Tag Prefix-Length IP-Address  GW-IPAddress  L3VNID/LABEL
Nexthop  Encap    Router-Mac
0         0      24          80.80.1.0    0.0.0.0        16
6.6.6.6   MPLS    e8c5:7aff:96de
0         0      24          90.90.1.0    0.0.0.0        16
6.6.6.6   MPLS    e8c5:7aff:96de
SH-1#

SH-1#sh bgp l2vpn evpn summary
BGP router identifier 5.5.5.5, local AS number 65010
BGP table version is 10
1 BGP AS-PATH entries
0 BGP community entries

Neighbor  AD  MACIP  V  AS  MsgRcv  MsgSen TblVer  InQ  OutQ  Up/Down  State/
PfxRcd
2.2.2.2   3   0      2   1   407     379    9      0    0  01:44:58
6
3.3.3.3   3   2      2   1   416     390    8      0    0  01:55:55
8
6.6.6.6   0   2      2   0   399     396    7      0    0  02:04:33
6

Total number of neighbors 3

Total number of Established sessions 3
SH-1#

SH-1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

```

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

(m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	4	2				
			1	-	Yes	LSP_DEFAULT	25601
xe6	No	30.30.30.2					
L>	3.3.3.3/32	7	40				
			39	-	Yes	LSP_DEFAULT	25607
xe6	No	30.30.30.2					
L>	4.4.4.4/32	2	35				
			7	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					
L>	6.6.6.6/32	3	37				
			36	-	Yes	LSP_DEFAULT	25603
xe6	No	30.30.30.2					
L>	10.10.10.0/24	1	35				
			7	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					
L>	20.20.20.0/24	6	35				
			7	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					
L>	40.40.40.0/24	5	35				
			7	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					

SH-1#

SH-1#sh ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe6	Active	OPERATIONAL	30	01:44:53
3.3.3.3	xe6	Active	OPERATIONAL	30	01:55:35
6.6.6.6	xe6	Passive	OPERATIONAL	30	01:57:21
4.4.4.4	xe6	Active	OPERATIONAL	30	01:57:21

SH-1#

SH-1#sh ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	
Instance ID						
4.4.4.4	1	Full/Backup	00:00:31	30.30.30.2	xe6	0

SH-1#

SH-2:

SH-2#sh evpn mpls

EVPN-MPLS Information

=====

Codes: NW - Network Port

AC - Access Port

(u) - Untagged

VPN-ID Status	EVI-Name Src-Addr	EVI-Type Dst-Addr	Type	Interface	ESI	VLAN	DF-
100 ---	---- 6.6.6.6	L2 3.3.3.3	NW	----	----	----	-
100 ---	---- 6.6.6.6	L2 2.2.2.2	NW	----	----	----	-
100 ---	---- 6.6.6.6	L2 5.5.5.5	NW	----	----	----	-
200 ---	---- 6.6.6.6	L2 3.3.3.3	NW	----	----	----	-
200 ---	---- 6.6.6.6	L2 2.2.2.2	NW	----	----	----	-
200 ---	---- 6.6.6.6	L2 5.5.5.5	NW	----	----	----	-

Total number of entries are 6

SH-2#

SH-2#sh evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
6.6.6.6	3.3.3.3	Installed	01:57:22	01:57:22	200
6.6.6.6	3.3.3.3	Installed	01:57:22	01:57:22	100
6.6.6.6	2.2.2.2	Installed	01:46:26	01:46:26	200
6.6.6.6	2.2.2.2	Installed	01:46:26	01:46:26	100
6.6.6.6	5.5.5.5	Installed	01:58:49	01:58:49	200
6.6.6.6	5.5.5.5	Installed	01:58:49	01:58:49	100

Total number of entries are 6

SH-2#

SH-2#sh evpn mpls mac-table

EVPN MPLS MAC Entries						
VNID Status	Interface MAC move	VlanId Access	In-VlanId PortDesc	Mac-Addr	VTEP-Ip/ESI	Type
100 Static Local	irb100 -----	----	0	0077.8899.5566	6.6.6.6	
100 Dynamic Remote	-----	----	0	0010.9400.0001	00:00:00:11:11:aa:aa:00:00:00	
200 Static Local	irb200 -----	----	0	0077.8899.5566	6.6.6.6	
200 Dynamic Remote	-----	----	0	0010.9400.0005	5.5.5.5	

Total number of entries are : 4

SH-2#

SH-2#sh evpn mpls arp-cache

MPLS-EVPN ARP-CACHE Information

=====

ARP Timeout : 300 sec Random-Jitter-Max : 200

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
100	80.80.1.2	0010.9400.0001	Dynamic Remote	----	
100	80.80.1.3	0077.8899.5566	Static Local	----	
200	90.90.1.3	0077.8899.5566	Static Local	----	
200	90.90.1.4	0010.9400.0005	Dynamic Remote	----	

Total number of entries are 4

SH-2#

SH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:64512]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	16	2.2.2.2	MPLS

RD[3.3.3.3:64512]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	16	3.3.3.3	MPLS

RD[6.6.6.6:100] VRF[red]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	16	2.2.2.2	MPLS
00:00:00:11:11:aa:aa:00:00:00	4294967295	16	3.3.3.3	MPLS

RD[6.6.6.6:200] VRF[blue]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	16	2.2.2.2	MPLS
00:00:00:11:11:aa:aa:00:00:00	4294967295	16	3.3.3.3	MPLS

SH-2#

SH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	2.2.2.2	MPLS

RD[2.2.2.2:200]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	2.2.2.2	MPLS

RD[3.3.3.3:100]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	3.3.3.3	MPLS

RD[3.3.3.3:200]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	3.3.3.3	MPLS

RD[6.6.6.6:100] VRF[red]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	100	17	2.2.2.2	MPLS
00:00:00:11:11:aa:aa:00:00:00	100	17	3.3.3.3	MPLS

RD[6.6.6.6:200] VRF[blue]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	200	18	2.2.2.2	MPLS
00:00:00:11:11:aa:aa:00:00:00	200	18	3.3.3.3	MPLS

SH-2#

SH-2#sh evpn mpls label esi

S - Self

R - Remote

ESI	PE-IP-ADDRESS	ESI-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	16
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (R)	16

SH-2#

SH-2#sh evpn mpls label alias

S - Self

R - Remote

ESI	PE-IP-ADDRESS	TENANT	ALIAS-LABEL
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	100	17
00:00:00:11:11:aa:aa:00:00:00	2.2.2.2 (R)	200	18
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (R)	100	17
00:00:00:11:11:aa:aa:00:00:00	3.3.3.3 (R)	200	18

SH-2#

SH-2#sh bgp l2vpn evpn

BGP table version is 9, local router ID is 6.6.6.6

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]

1 - Ethernet Auto-discovery Route

2 - MAC/IP Route

3 - Inclusive Multicast Route

4 - Ethernet Segment Route

5 - Prefix Route

Network	Next Hop	Metric	LocPrf	Weight	Path	Peer
Encap						

RD[2.2.2.2:100]

*>i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]

```

                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>i  [3]:[100]:[32,2.2.2.2]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS

RD[2.2.2.2:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>i  [3]:[200]:[32,2.2.2.2]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS

RD[2.2.2.2:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                2.2.2.2          0          100          0    i  2.2.2.2          MPLS

RD[3.3.3.3:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [3]:[100]:[32,3.3.3.3]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [3]:[200]:[32,3.3.3.3]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                3.3.3.3          0          100          0    i  3.3.3.3          MPLS

RD[5.5.5.5:100]
*>i  [3]:[100]:[32,5.5.5.5]
                5.5.5.5          0          100          0    i  5.5.5.5          MPLS

RD[5.5.5.5:200]
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
                5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
                5.5.5.5          0          100          0    i  5.5.5.5          MPLS
*>i  [3]:[200]:[32,5.5.5.5]
                5.5.5.5          0          100          0    i  5.5.5.5          MPLS

```

RD[6.6.6.6:100] VRF[red]:

```
* i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
      2.2.2.2 0 100 0 i 2.2.2.2 MPLS
* i 3.3.3.3 0 100 0 i 3.3.3.3 MPLS
* i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
      2.2.2.2 0 100 0 i 2.2.2.2 MPLS
* i 3.3.3.3 0 100 0 i 3.3.3.3 MPLS
* i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
      3.3.3.3 0 100 0 i 3.3.3.3 MPLS
* i [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
      3.3.3.3 0 100 0 i 3.3.3.3 MPLS
*> [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]
      6.6.6.6 0 100 32768 i ----- MPLS
* i [3]:[100]:[32,2.2.2.2]
      2.2.2.2 0 100 0 i 2.2.2.2 MPLS
* i [3]:[100]:[32,3.3.3.3]
      3.3.3.3 0 100 0 i 3.3.3.3 MPLS
* i [3]:[100]:[32,5.5.5.5]
      5.5.5.5 0 100 0 i 5.5.5.5 MPLS
*> [3]:[100]:[32,6.6.6.6]
      6.6.6.6 0 100 32768 i ----- MPLS
```

RD[6.6.6.6:200] VRF[blue]:

```
* i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
      2.2.2.2 0 100 0 i 2.2.2.2 MPLS
* i 3.3.3.3 0 100 0 i 3.3.3.3 MPLS
* i [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
      2.2.2.2 0 100 0 i 2.2.2.2 MPLS
* i 3.3.3.3 0 100 0 i 3.3.3.3 MPLS
* i [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
      5.5.5.5 0 100 0 i 5.5.5.5 MPLS
* i [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
      5.5.5.5 0 100 0 i 5.5.5.5 MPLS
*> [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
      6.6.6.6 0 100 32768 i ----- MPLS
* i [3]:[200]:[32,2.2.2.2]
      2.2.2.2 0 100 0 i 2.2.2.2 MPLS
* i [3]:[200]:[32,3.3.3.3]
      3.3.3.3 0 100 0 i 3.3.3.3 MPLS
* i [3]:[200]:[32,5.5.5.5]
      5.5.5.5 0 100 0 i 5.5.5.5 MPLS
*> [3]:[200]:[32,6.6.6.6]
      6.6.6.6 0 100 32768 i ----- MPLS
```

Total number of prefixes 36

SH-2#

SH-2#sh bgp l2vpn evpn prefix-route

SH-2#

SH-2#sh bgp l2vpn evpn summary

BGP router identifier 6.6.6.6, local AS number 65010

BGP table version is 9
 1 BGP AS-PATH entries
 0 BGP community entries

Neighbor PfxRcd	AD	MACIP	V MCAST	AS	MsgRcv ESI	MsgSen PREFIX-ROUTE	TblVer	InQ	OutQ	Up/Down	State/
2.2.2.2			4	65010	410	398	8	0	0	01:46:28	
6	3	0	2	1	0						
3.3.3.3			4	65010	422	402	7	0	0	01:57:25	
8	3	2	2	1	0						
5.5.5.5			4	65010	391	406	5	0	0	02:06:03	
4	0	2	2	0	0						

Total number of neighbors 3

Total number of Established sessions 3

SH-2#

SH-2#sh ip bgp vrf evpn_anycast

BGP table version is 1, local router ID is 90.90.1.3

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

	Network	Next Hop	Metric	LocPrf	Weight	Path
*>	80.80.1.0/24	0.0.0.0	0	100	32768	?
*>	90.90.1.0/24	0.0.0.0	0	100	32768	?

Total number of prefixes 2

SH-2#

SH-2#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

(m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	4	3				
			2	-	Yes	LSP_DEFAULT	25604
xe14	No	40.40.40.2					
L>	3.3.3.3/32	7	41				
			40	-	Yes	LSP_DEFAULT	25608
xe14	No	40.40.40.2					
L>	4.4.4.4/32	3	39				
			11	-	Yes	LSP_DEFAULT	3
xe14	No	40.40.40.2					
L>	5.5.5.5/32	1	34				
			33	-	Yes	LSP_DEFAULT	25602
xe14	No	40.40.40.2					
L>	10.10.10.0/24	2	39				


```

xe14      No      40.40.40.2      11      -      Yes      LSP_DEFAULT  3
  L>      20.20.20.0/24      6      39
xe14      No      40.40.40.2      11      -      Yes      LSP_DEFAULT  3
  L>      30.30.30.0/24      5      39
xe14      No      40.40.40.2      11      -      Yes      LSP_DEFAULT  3
SH-2#
SH-2#sh ldp session
Peer IP Address      IF Name      My Role      State      KeepAlive      UpTime
2.2.2.2              xe14         Active       OPERATIONAL 30      01:46:21
3.3.3.3              xe14         Active       OPERATIONAL 30      01:57:03
5.5.5.5              xe14         Active       OPERATIONAL 30      01:58:50
4.4.4.4              xe14         Active       OPERATIONAL 30      01:58:50
SH-2#
SH-2#sh ip ospf neighbor

```

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
4.4.4.4	1	Full/Backup	00:00:30	40.40.40.2	xe14	0

SH-2#

SH-2#sh nvo vxlan l3vni-map

L3VNI	L2VNI	IRB-interface
10000	100	irb100
10000	200	irb200

SH-2#

P1:

P1#sh ip ospf neighbor

Total number of full neighbors: 4

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
2.2.2.2 0	1	Full/Backup	00:00:35	10.10.10.1	xe4.1	
3.3.3.3	1	Full/Backup	00:00:37	20.20.20.1	xe1	0
5.5.5.5	1	Full/DR	00:00:38	30.30.30.1	xe6	0
6.6.6.6	1	Full/DR	00:00:36	40.40.40.1	xe10	0

P1#

P1#sh ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
3.3.3.3	xe1	Active	OPERATIONAL	30	01:58:40
2.2.2.2	xe4.1	Active	OPERATIONAL	30	01:47:32

```

5.5.5.5          xe6          Passive  OPERATIONAL  30    02:00:03
6.6.6.6          xe10         Passive  OPERATIONAL  30    02:00:03

```

```
P1#
```

```
P1#sh mpls forwarding-table
```

```

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	2	2				
			1	-	Yes	LSP_DEFAULT	3
xe4.1	No	10.10.10.1					
L>	3.3.3.3/32	4	47				
			46	-	Yes	LSP_DEFAULT	3
xe1	No	20.20.20.1					
L>	5.5.5.5/32	1	38				
			37	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.1					
L>	6.6.6.6/32	3	44				
			43	-	Yes	LSP_DEFAULT	3
xe10	No	40.40.40.1					

```

P1#

```

EVPN MPLS IRB Symmetric with Host Routes

Overview

EVPN-IRB facilitates communication between two L2VNI's with the help of Routing using IP-VRF. This features provides the Host (/32 or /128) based Symmetric IRB support which forwards the inter-subnet traffic directly towards the host (CEs) attached to VTEP (PEs).

Host based Symmetric IRB support is two modes: interface-full and interface-less.

- Interface-full mode refers to configuring of IRB interface
- Interface-less mode refers to configuring the access interface as L3 interface and using the IRB configuration. IRB interface is not used in this case.
- Interface-full mode supports “evpn irb-advertise-host-route” CLI under evpn mpls id <id>.
- Interface-less mode supports both “evpn irb-advertise-host-route” CLI under evpn mpls id <id> and “redistribute-connected-host-routes” under bgp vrf address family.
- Host based Symmetric IRB support is achieved through one of the modes:
 - “evpn irb-advertise-host-route” in interface-full mode (with IRB interface)
 - evpn irb-advertise-host-route” in interface-less mode (without IRB interface)
 - “redistribute-connected-host-routes” in interface-less mode (without IRB interface)

Topology

Figure 2-6 depicts the EVPN MPLS IRB with LDP as underlay MPLS path.

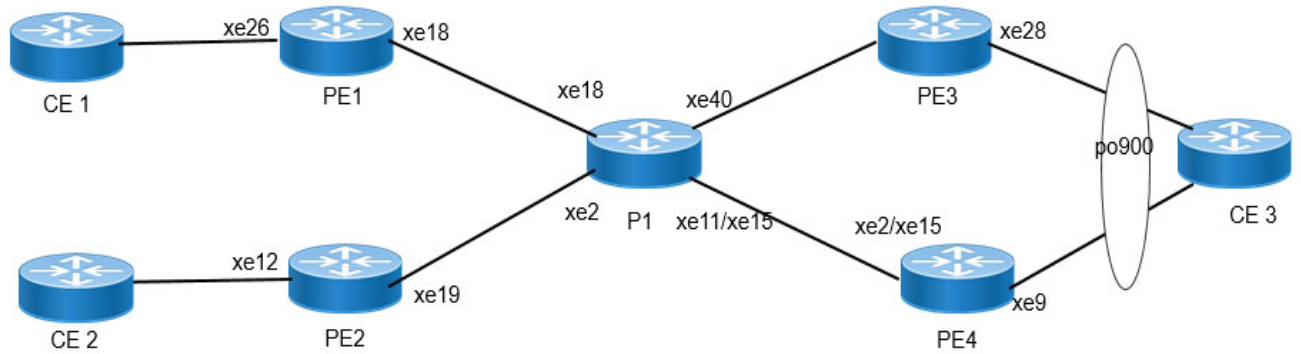


Figure 2-6: Host based symmetric IRB support

PE1

Enable EVPN MPLS and IRB

#configure terminal	Enter configuration mode.
(config)#evpn mpls enable	Enable EVPN MPLS globally.
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally.

Loopback Interface

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 20.20.20.20/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode.

Configure MAC VRF:

(config)#mac vrf green	Create MAC VRF mvrf4.
(config-vrf)# rd 20.20.20.20:400	Configure route distinguisher.
(config-vrf)# route-target both 65010:400	Configure route target as evpn auto route target (it can be configured as manual RT).
(config-vrf)#exit	Exit VRF mode.

Configure IP VRF:

(config)#ip vrf vrf400	Configure IP VRF vrf100.
(config-vrf)# rd 30:400	Configure route distinguisher
(config-vrf)# route-target both 100:400	Configure route target
(config-vrf)# l3vni 40000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configure anycast gateway MAC:

(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.5577	Configure anycast gateway MAC globally.
---	---

Configuring IRB interface:

(config)#interface irb400	Create IRB interface irb100.
(config-irb-if)# ip vrf forwarding vrf400	Map L3 VRF to the IRB interface.
(config-irb-if)# ip address 40.40.1.1/24 anycast	Assign IP address.
(config-irb-if)# ipv6 address 5001::1/48	Assign IPv6 address.
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC.
(config-irb-if)#exit	Exit interface mode.

Creating EVPN MPLS ID:

(config)#evpn mpls vtep-ip-global 20.20.20.20	Configure VTEP global IP.
(config)#evpn mpls id 400	Create EVPN MPLS ID.
(config-evpn-mpls)# host-reachability- protocol evpn-bgp green	Map the MAC VRF mvrf4.
(config-evpn-mpls)# evpn irb irb400	Map the IRB interface.
(config-evpn-mpls)# evpn irb-advertise- host-route	Set host to route advertise.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode.

Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)# router-id 20.20.20.20	Set router ID of LDP.
(config-router)# targeted-peer ipv4 17.17.17.17	Configure targeted peer.
(config-router-targeted-peer)# exit	Exit from targeted-peer mode.

(config-router)# transport-address ipv4 20.20.20.20	Configure LDP transport address.
(config-router)#exit	Exit from LDP mode.

Interface Configuration Network Side

(config)#interface xe18	Configure physical interface.
(config-if)# mtu 9216	Configure MTU on the interface.
(config-if)# load-interval 30	Set load interval.
(config-if)# ip address 55.55.55.1/24	Assign IP address.
(config-if)# label-switching	Enable label switching.
(config-if)# isis network point-to-point	Configure isis as point-to-point network.
(config-if)# enable-ldp ipv4	Enable LDP IPv4.
(config-if)# ip router isis ISIS-IGP	Enable a routing process.
(config-if)#exit	Exit interface mode.
(config-if)# router isis ISIS-IGP	Enter the Router ISIS mode.
(config-router)# is-type level-1	IS Level for this routing process.
(config-router)# mpls traffic-eng router-id 20.20.20.20	Routing protocol commands for MPLS Traffic Engineering.
(config-router)# net 49.0001.0000.0000.0001.00	Configure net.
(config-router)#exit	Exit OSPF mode.

BGP Configuration

(config)#router bgp	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 11.11.11.11 remote-as 65010	Configuring PE3 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 11.11.11.11 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 22.22.22.22 remote-as 65010	Configuring PE2 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 22.22.22.22 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 17.17.17.17 remote-as 65010	Configuring PE3 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 22.22.22.22 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 11.11.11.11 activate	Enabling EVPN Address family for neighbor

(config-router-af)# neighbor 22.22.22.22 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 17.17.17.17 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf vrf400	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration:

(config)# interface xe26	Configure physical interface
(config-if)# static-channel-group 10000	Create static channel group
(config-if)# exit	Exit interface mode
(config)# interface sa10000	Configure Static channel sa10000
(config-if)# switchport	Make it L2 interface
(config-if)# load-interval 30	Set load interval
(config-if)# mtu 9216	Configure MTU on the interface.
(config)# exit	Exit interface mode
(config)# interface sa10000.400 switchport	Configure static sub-interface
(config-if)# encapsulation dot1q 701	Configure encapsulation
(config-if)# rewrite pop	Pop the outer VID
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 400	Map VPN-ID 400
(config-acc-if-evpn)# mac 0000.0000.aaaa ip 40.40.1.10	Configure static mac with IP
(config-acc-if-evpn)# mac 0000.0000.bbbb ipv6 5001:aaaa::1	Configure static mac with IPv6
(config-acc-if-evpn)#exit	Exiting out of access interface mode

PE2

Enable EVPN MPLS and IRB:

#configure terminal	Enter configuration mode.
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally

Loopback Interface

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 22.22.22.22/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF

(config)#mac vrf green	Create MAC VRF mvrf4.
(config-vrf)# rd 22.22.22.22:400	Configure route distinguisher
(config-vrf)# route-target both 65010:400	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF

(config)#ip vrf vrf400	Configure IP VRF vrf100.
(config-vrf)# rd 40:400	Configure route distinguisher
(config-vrf)# route-target both 100:400	Configure route target
(config-vrf)# l3vni 40000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configure anycast gateway MAC

(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.5577	Configure anycast gateway MAC globally
---	--

Configuring IRB interface

(config)#interface irb400	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding vrf400	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 40.40.1.1/24 anycast	Assign IP address
(config-irb-if)# ipv6 address 5001::1/48	Assign IPv6 address
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID:

(config)#evpn mpls vtep-ip-global 22.22.22.22	Configure VTEP global IP
(config)#evpn mpls id 400	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachability-protocol evpn-bgp green	Map the MAC VRF mvrf4
(config-evpn-mpls)# evpn irb irb400	Map the IRB interface
(config-evpn-mpls)# evpn irb-advertise-host-route	Set host to route advertise
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)# router-id 22.22.22.22	Set router ID of LDP
(config-router)# targeted-peer ipv4 17.17.17.17	Configure targeted peer
(config-router)# targeted-peer ipv4 11.11.11.11	Configure targeted peer
(config-router-targeted-peer)# exit	Exit from targeted-peer mode
(config-router)# transport-address ipv4 22.22.22.22	Configure LDP transport address
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side

(config)#interface xe19	Configure physical interface
(config-if)# mtu 9216	Configure MTU on the interface.
(config-if)# load-interval 30	Set load interval
(config-if)# ip address 30.30.30.1/24	Assign IP address
(config-if)# label-switching	Enable label switching
(config-if)# isis network point-to-point	Configure isis as point-to-point network
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)# ip router isis ISIS-IGP	Enable a routing process
(config-if)#exit	Exit interface mode
(config-if)# router isis ISIS-IGP	Enter the Router ISIS mode.
(config-router)# is-type level-1	IS Level for this routing process
(config-router)# mpls traffic-eng router-id 22.22.22.22	routing protocol commands for MPLS Traffic Engineering

(config-router)# net 49.0001.0000.0000.0006.00	Configure net
(config-router)#exit	Exit OSPF mode

BGP Configuration

(config)#router bgp	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 11.11.11.11 remote-as 65010	Configuring PE3 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 11.11.11.11 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 20.20.20.20 remote-as 65010	Configuring PE2 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 20.20.20.20 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 17.17.17.17 remote-as 65010	Configuring PE3 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 17.17.17.17 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 11.11.11.11 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 22.22.22.22 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 17.17.17.17 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf vrf400	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration

(config)# interface xe12.400 switchport	Configure static sub-interface
(config-if)# encapsulation dot1q 400	Configure encapsulation
(config-if)# rewrite pop	Pop the outer VID
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 400	Map VPN-ID 400
(config-acc-if-evpn)# mac 0000.0000.aabb ip 40.40.1.20	Configure static mac with IP

(config-acc-if-evpn) # mac 0000.0000.bbaa ipv6 5001::20	Configure static mac with IPv6
(config-acc-if-evpn) #exit	Exiting out of access interface mode

P1

Loopback Interface:

#configure terminal	Enter configuration mode.
(config-if) #interface lo	Enter the Interface mode for the loopback interface.
(config-if) # ip address 24.24.24.24/32 secondary	Configure IP address on loopback interface.
(config-if) #exit	Exit interface mode

Global LDP

(config) #router ldp	Enter the Router LDP mode.
(config-router) # router-id 24.24.24.24	Configure router id
(config-router) # transport-address ipv4 24.24.24.24	Configure transport address

Interface Configuration

(config) #interface xe2	Configure physical interface
(config-if) # mtu 9216	Configure MTU on the interface.
(config-if) # load-interval 30	Set load interval
(config-if) # ip address 30.30.30.2/24	Assign IP address
(config-if) # label-switching	Enable label switching
(config-if) # isis network point-to-point	Configure isis as point-to-point network
(config-if) # enable-ldp ipv4	Enable LDP IPv4
(config-if) #exit	Exit interface mode
(config) #interface xe18	Configure physical interface
(config-if) # mtu 9216	Configure MTU on the interface.
(config-if) # load-interval 30	Set load interval
(config-if) # ip address 55.55.55.2/24	Assign IP address
(config-if) # label-switching	Enable label switching
(config-if) # isis network point-to-point	Configure isis as point-to-point network
(config-if) # enable-ldp ipv4	Enable LDP IPv4
(config-if) #exit	Exit interface mode
(config) #interface xe40	Configure physical interface
(config-if) # mtu 9216	Configure MTU on the interface.

(config-if)# load-interval 30	Set load interval
(config-if)# ip address 76.76.76.2/24	Enter interface mode xe40
(config-if)# label-switching	Set label switching
(config-if)# isis network point-to-point	Set routing protocol isis
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#exit	Exit interface mode
(config-if)# mtu 1522	Configure MTU on the interface.
(config-if)#exit	Exit interface mode.
(config)# interface xe11	Create po subinterface
(config-if)# ip address 60.60.60.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)# isis network point-to-point	Set routing protocol isis
(config-if)#exit	Exit interface mode

ISIS Configuration

(config)#router isis ISIS-IGP	Enter the Router Isis mode.
(config-router)# is-type level-1	IS Level for this routing process
(config-router)# mpls traffic-eng router-id 24.24.24.24	routing protocol commands for MPLS Traffic Engineering
(config-router)# net 49.0001.0000.0000.0003.00	Configure net
(config-router)#exit	Exit Router isis mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

PE3

Enable EVPN MPLS and IRB

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mpls-mh enable	Configure hardware profile to enable EVPN MPLS multi homing in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 11.11.11.11/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF

(config-vrf)#mac vrf green	Create MAC VRF mvrf4.
(config-vrf)# rd 11.11.11.11:400	Configure route distinguisher
(config-vrf)# route-target both 65010:400	Configure route target as evpn auto-rt(we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF

(config)#ip vrf vrf400	Configure IP VRF vrf100.
(config-vrf)# rd 20:400	Configure route distinguisher
(config-vrf)# route-target both 100:400	Configure route target
(config-vrf)# l3vni 40000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configure Anycast Gateway MAC

(config)#evpn irb-forwarding anycastgateway- mac 0011.2233.4455	Configure anycast gateway MAC globally
(config)#interface irb500	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding vrf400	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 80.80.1.1/24 anycast	Assign IP address
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID

(config)#evpn mpls vtep-ip-global 11.11.11.11	Configure VTEP global IP
(config)#evpn mpls id 500	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachability- protocol evpn-bgp green	Map the MAC VRF mvrf4

(config-evpn-mpls)# evpn irb irb500	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP

(config)#router ldp	Enter the Router LDP mode
(config-router)# transport-address ipv4 11.11.11.11	Configure LDP transport address
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side

(config-if)#interface xe27	Enter the Interface mode for eth10.
(config-if)# mtu 9216	Configure MTU.
(config-if)# enable-ldp ipv4	Enable LDP on the physical interface
(config-if)# ip address ip address 76.76.76.1/24	Assign IP address
(config-if)# mtu 1522	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# isis network point-to-point	Configure isis as point-to-point network
(config-if)# router isis ISIS-IGP	Configure isis with ISIS-IGP area tag
(config-if)# exit	Exit interface mode

ISIS Configuration

(config)# router isis ISIS-IGP	Enter the Router ISIS mode.
(config-router)# is-type level-1	IS Level for this routing process
(config-router)# mpls traffic-eng router-id 11.11.11.11	Routing protocol commands for MPLS Traffic Engineering
(config-router)# net 49.0001.0000.0000.0005.00	Configure net

BGP Configuration

(config-router)# router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)# neighbor 20.20.20.20 remote-as 65010	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 20.20.20.20 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 22.22.22.22 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP

(config-router)# neighbor 22.22.22.22 update-source lo lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 20.20.20.20 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 22.22.22.22 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf Vrf400	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration

(config)#interface po900	Create LAG interface po900
(config-if)# switchport	Configure as switchport
(config-if)# evpn multi-homed system-mac 0000.1111.aaaa	Configure system MAC for multi homing
(config)#interface po900.500 switchport	Creating L2 sub interface of physical interface xe28
(config-if)# encapsulation dot1q 500	Setting Encapsulation to dot1q with VLAN ID 500
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 500	Map VPN-ID 500
(config-acc-if-evpn)#exit	Exiting out of access interface mode

PE4

Enable EVPN MPLS and IRB

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mpls- mh enable	Configure hardware profile to enable EVPN MPLS multi homing in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface

(config-if)#interface lo	Enter the Interface mode for the loopback interface
--------------------------	---

(config-if)# ip address 17.17.17/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF

(config-vrf)#mac vrf green	Create MAC VRF mvrf4.
(config-vrf)# rd 17.17.17.17:400	Configure route distinguisher
(config-vrf)# route-target both 65010:400	Configure route target as evpn auto-rt (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF

(config)#ip vrf vrf400	Configure IP VRF vrf100.
(config-vrf)# rd 10:400	Configure route distinguisher
(config-vrf)# route-target both 100:400	Configure route target
(config-vrf)# l3vni 40000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configure Anycast Gateway MAC

(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.5577	Configure anycast gateway MAC globally
---	--

Configuring IRB interface

(config)#interface irb500	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding vrf400	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 80.80.1.1/24 anycast	Assign IP address
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID

(config)#evpn mpls vtep-ip-global 17.17.17.17	Configure VTEP global IP
(config)#evpn mpls id 500	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachability- protocol evpn-bgp green	Map the MAC VRF green

(config-evpn-mpls)# evpn irb irb500	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 17.17.17.17	Configure lo under ldp
(config-router)#targeted-peer ipv4 20.20.20.20	Configure targeted peer
(config-router-targeted-peer)# exit-targeted-peer-mode	Exit target peer mode
(config-router)# targeted-peer ipv4 22.22.22.22	Configure targeted peer
(config-router-targeted-peer)# exit-targeted-peer-mode	Exit target peer mode
(config-router)# transport-address ipv4 17.17.17.17	Configure LDP transport address
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side

(config-if)#interface xe2	Configure physical interface
(config-if)# ip address 60.60.60.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# isis network point-to-point	Configure ISIS as point-to-point network
(config-if)# ip router isis ISIS-IGP	Configure ISIS with area tag ISIS-IGP
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

ISIS Configuration

(config)# router isis ISIS-IGP	Enter the Router OSPF mode.
(config-router)# is-type level-1	Configure routing ISIS level
(config-router)# mpls traffic-eng router-id 17.17.17.17	Routing protocol commands for MPLS Traffic Engineering.
(config-router)# net 49.0001.0000.0000.0004.00	Configure net

BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 100
(config-router)# bgp router-id 17.17.17.17	
(config-router)# neighbor 20.20.20.20 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 20.20.20.20 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 22.22.22.22 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 22.22.22.21 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 20.20.20.20 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 22.22.22.22 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf Vrf500	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration

(config)#interface po900	Create LAG interface po1
(config-if)# switchport	Configure as switchport
(config-if)# evpn multi-homed system-mac 0000.0000.1111	Configure system MAC for multi homing
(config)#interface po900.500 switchport	Creating L2 sub interface of physical interface xe9
(config-if)# encapsulation dot1q 500	Setting Encapsulation to dot1q with VLAN ID 500
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 500	Map VPN-ID 500
(config-acc-if-evpn)#exit	Exiting out of access interface mode

Validation

PE1

```
SH-1-7020#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	evpn-id
--------	-------------	--------	---------	--------	---------

```
=====
20.20.20.20      17.17.17.17      Installed      17:04:56      17:04:56      701
20.20.20.20      17.17.17.17      Installed      17:04:56      17:04:56      700
20.20.20.20      17.17.17.17      Installed      17:04:56      17:04:56      600
20.20.20.20      17.17.17.17      Installed      21:39:09      21:39:09      40000
20.20.20.20      22.22.22.22      Installed      21:39:09      21:39:09      40000
20.20.20.20      22.22.22.22      Installed      13:59:58      13:59:58      400
20.20.20.20      11.11.11.11      Installed      17:04:56      17:04:56      701
20.20.20.20      11.11.11.11      Installed      17:04:56      17:04:56      700
20.20.20.20      11.11.11.11      Installed      17:04:56      17:04:56      600
20.20.20.20      11.11.11.11      Installed      17:04:56      17:04:56      400
20.20.20.20      11.11.11.11      Installed      21:39:09      21:39:09      40000
=====
```

Total number of entries are 11

SH-1-7020#show evpn mpls mac-table

```
=====
EVPN MPLS MAC Entries
=====
VNID      Interface VlanId  In-VlanId Mac-Addr      VTEP-Ip/ESI      Type
Status      MAC move AccessPortDesc

400      irb400      ----      ----      0011.2233.5577 20.20.20.20
Static Local      -----      0      -----
400      sa10000.400 ----      ----      0000.0000.aaaa 20.20.20.20
Static Local      -----      0      -----
400      sa10000.400 ----      ----      0000.0000.bbbb 20.20.20.20
Static Local      -----      0      -----
```

Total number of entries are: 3

SH-1-7020#show evpn mpls arp-cache

MPLS-EVPN ARP-CACHE Information

```
=====
EVPN-ID    Ip-Addr          Mac-Addr          Type          Age-Out    Retries-Left
400        40.40.1.1        0011.2233.5577 Static Local    ----
400        40.40.1.10       0000.0000.aaaa Static Local    ----
```

Total number of entries are 2

SH-1-7020#show evpn mpls nd-cache

MPLS-EVPN ND-CACHE Information

```
=====
EVPN-ID    Ip-Addr          Mac-Addr          Type          Age-Out    Retries-Left
400        5001::1          0011.2233.5577 Static Local    ----
400        5001:aaaa::1     0000.0000.bbbb Static Local    ----
```

Total number of entries are 2

SH-1-7020#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[11.11.11.11:64512]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	38	11.11.11.11	MPLS

RD[17.17.17.17:64512]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	37	17.17.17.17	MPLS

PE2

SH2-7022#show evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
22.22.22.22	11.11.11.11	Installed	14:21:58	14:21:58	400
22.22.22.22	11.11.11.11	Installed	19:56:30	19:56:30	40000
22.22.22.22	17.17.17.17	Installed	19:56:30	19:56:30	40000
22.22.22.22	20.20.20.20	Installed	14:30:31	14:30:31	400
22.22.22.22	20.20.20.20	Installed	19:56:30	19:56:30	40000

Total number of entries are 5

SH2-7022#show evpn mpls mac-table

```

=====
                                     EVPN MPLS MAC Entries
=====
VNID      Interface VlanId  In-VlanId Mac-Addr      VTEP-Ip/ESI      Type
Status      MAC move AccessPortDesc
=====
400      irb400      ----      ----      0011.2233.5577 22.22.22.22
Static Local      -----      0      -----
400      ----      ----      ----      0000.0000.aaaa 20.20.20.20
Static Remote      -----      0      -----
400      ----      ----      ----      0000.0000.bbbb 20.20.20.20
Static Remote      -----      0      -----

```

Total number of entries are : 3

SH2-7022#sh evpn mpls arp-cache

MPLS-EVPN ARP-CACHE Information

```

=====
EVPN-ID  Ip-Addr      Mac-Addr      Type      Age-Out  Retries-Left
=====
400      40.40.1.1      0011.2233.5577 Static Local  ----
400      40.40.1.10      0000.0000.aaaa Static Remote  ----
Total number of entries are 2

```

SH2-7022#sh evpn mpls nd-cache

MPLS-EVPN ND-CACHE Information

=====

EVPN-ID Left	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-
-----------------	---------	----------	------	---------	----------

400	5001::1	0011.2233.5577	Static Local	----	
400	5001:aaaa::1	0000.0000.bbbb	Static Remote	----	

Total number of entries are 2

SH2-7022#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[11.11.11.11:64512]					
ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap	
00:00:00:11:11:aa:aa:00:00:00	4294967295	38	11.11.11.11	MPLS	

RD[17.17.17.17:64512]					
ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap	
00:00:00:11:11:aa:aa:00:00:00	4294967295	37	17.17.17.17	MPLS	

SH2-7022#sh bgp l2vpn evpn

BGP table version is 11, local router ID is 22.22.22.22

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]

- 1 - Ethernet Auto-discovery Route
- 2 - MAC/IP Route
- 3 - Inclusive Multicast Route
- 4 - Ethernet Segment Route
- 5 - Prefix Route

Network Encap	Next Hop	Metric	LocPrf	Weight	Path	Peer
------------------	----------	--------	--------	--------	------	------

RD[10:400]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	17.17.17.17	0	100	0	?	17.17.17.17 MPLS

RD[20:400]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	11.11.11.11	0	100	0	?	11.11.11.11 MPLS

RD[30:400]						
*>i [5]:[0]:[0]:[24]:[40.40.1.0]:[0.0.0.0]:[16]	20.20.20.20	0	100	0	?	20.20.20.20 MPLS

RD[11.11.11.11:400]						
*>i [2]:[0]:[500]:[48,0011:2233:5577]:[32,80.80.1.1]:[18]	11.11.11.11	0	100	0	i	11.11.11.11 MPLS
*>i [3]:[400]:[32,11.11.11.11]						

```

11.11.11.11      0      100      0      i  11.11.11.11      MPLS
*>i  [3]:[500]:[32,11.11.11.11]
11.11.11.11      0      100      0      i  11.11.11.11      MPLS

RD[17.17.17.17:400]
*>i  [2]:[0]:[500]:[48,0011:2233:5577]:[32,80.80.1.1]:[17]
17.17.17.17      0      100      0      i  17.17.17.17      MPLS
*>i  [3]:[500]:[32,17.17.17.17]
17.17.17.17      0      100      0      i  17.17.17.17      MPLS

RD[17.17.17.17:600]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[600]:[18]
17.17.17.17      0      100      0      i  17.17.17.17      MPLS
*>i  [3]:[600]:[32,17.17.17.17]
17.17.17.17      0      100      0      i  17.17.17.17      MPLS

RD[20.20.20.20:400]
*>i  [2]:[0]:[400]:[48,0000:0000:aaaa]:[32,40.40.1.10]:[17]:[16]
20.20.20.20      0      100      0      i  20.20.20.20      MPLS
*>i  [2]:[0]:[400]:[48,0000:0000:bbbb]:[128,5001:aaaa::1]:[17]
20.20.20.20      0      100      0      i  20.20.20.20      MPLS
*>i  [2]:[0]:[400]:[48,0011:2233:5577]:[32,40.40.1.1]:[17]
20.20.20.20      0      100      0      i  20.20.20.20      MPLS
*>i  [2]:[0]:[400]:[48,0011:2233:5577]:[128,5001::1]:[17]
20.20.20.20      0      100      0      i  20.20.20.20      MPLS
*>i  [3]:[400]:[32,20.20.20.20]
20.20.20.20      0      100      0      i  20.20.20.20      MPLS

RD[20.20.20.20:600]
*>i  [3]:[600]:[32,20.20.20.20]
20.20.20.20      0      100      0      i  20.20.20.20      MPLS

RD[20.20.20.20:700]
*>i  [3]:[0]:[32,20.20.20.20]
20.20.20.20      0      100      0      i  20.20.20.20      MPLS

RD[20.20.20.20:701]
*>i  [2]:[0]:[701]:[48,0000:0000:2001]:[0]:[29]
20.20.20.20      0      100      0      i  20.20.20.20      MPLS
*>i  [2]:[0]:[701]:[48,0000:0000:2002]:[32,20.20.20.1]:[29]
20.20.20.20      0      100      0      i  20.20.20.20      MPLS
*>i  [2]:[0]:[701]:[48,0000:0000:2003]:[128,1204::1]:[29]
20.20.20.20      0      100      0      i  20.20.20.20      MPLS
*>i  [3]:[701]:[32,20.20.20.20]
20.20.20.20      0      100      0      i  20.20.20.20      MPLS

RD[22.22.22.22:400] VRF[green]:
* i  [2]:[0]:[400]:[48,0000:0000:aaaa]:[32,40.40.1.10]:[17]:[16]
20.20.20.20      0      100      0      i  20.20.20.20      MPLS
* i  [2]:[0]:[400]:[48,0000:0000:bbbb]:[128,5001:aaaa::1]:[17]

```

```

                20.20.20.20          0          100          0    i  20.20.20.20      MPLS
*>  [2]:[0]:[400]:[48,0011:2233:5577]:[32,40.40.1.1]:[17]
                22.22.22.22          0          100          32768  i  -----
MPLS
* i          20.20.20.20          0          100          0    i  20.20.20.20      MPLS
*>  [2]:[0]:[400]:[48,0011:2233:5577]:[128,5001::1]:[17]
                22.22.22.22          0          100          32768  i  -----
MPLS
* i          20.20.20.20          0          100          0    i  20.20.20.20      MPLS
* i  [2]:[0]:[500]:[48,0011:2233:5577]:[32,80.80.1.1]:[18]
                11.11.11.11          0          100          0    i  11.11.11.11      MPLS
* i          17.17.17.17          0          100          0    i  17.17.17.17      MPLS
* i  [3]:[400]:[32,11.11.11.11]
                11.11.11.11          0          100          0    i  11.11.11.11      MPLS
* i  [3]:[400]:[32,20.20.20.20]
                20.20.20.20          0          100          0    i  20.20.20.20      MPLS
*>  [3]:[400]:[32,22.22.22.22]
                22.22.22.22          0          100          32768  i  -----
MPLS
* i  [3]:[500]:[32,11.11.11.11]
                11.11.11.11          0          100          0    i  11.11.11.11      MPLS
* i  [3]:[500]:[32,17.17.17.17]
                17.17.17.17          0          100          0    i  17.17.17.17      MPLS

```

Total number of prefixes 50

PE3

MH-2-7011#show evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
11.11.11.11	22.22.22.22	Installed	15:23:05	15:23:05	400
11.11.11.11	22.22.22.22	Installed	23:11:42	23:11:42	40000
11.11.11.11	17.17.17.17	Installed	18:36:34	18:36:34	500
11.11.11.11	17.17.17.17	Installed	23:11:42	23:11:42	40000
11.11.11.11	20.20.20.20	Installed	18:36:34	18:36:34	400
11.11.11.11	20.20.20.20	Installed	23:11:42	23:11:42	40000

MH-2-7011#show evpn mpls mac-table

```

=====
=====
                                EVPN MPLS MAC Entries
=====
=====
VNID      Interface VlanId  In-VlanId Mac-Addr      VTEP-Ip/ESI      Type
Status    MAC move AccessPortDesc
-----
400        ----      ----      ----      0011.2233.5577  20.20.20.20
Static Remote -----      0      -----

```

```

400      ----      ----      ----      0000.0000.aaaa 20.20.20.20
Static Remote      ----      0      ----
400      ----      ----      ----      0000.0000.bbbb 20.20.20.20
Static Remote      ----      0      ----
500      irb500      ----      ----      0011.2233.5577 11.11.11.11
Static Local      ----      0      ----

```

MH-2-7011#show evpn mpls arp-cache

MPLS-EVPN ARP-CACHE Information

=====

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
400	40.40.1.1	0011.2233.5577	Static Remote	----	
400	40.40.1.10	0000.0000.aaaa	Static Remote	----	
500	80.80.1.1	0011.2233.5577	Static Local	----	

Total number of entries are 3

MH-2-7011#show evpn mpls nd-cache

MPLS-EVPN ND-CACHE Information

=====

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
400	5001::1	0011.2233.5577	Static Remote	----	
400	5001:aaaa::1	0000.0000.bbbb	Static Remote	----	

Total number of entries are 2

MH-2-7011#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[11.11.11.11:64512] VRF[evpn-gvrf-1]:

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	38	11.11.11.11	MPLS

RD[17.17.17.17:64512]

ESI	Eth-Tag	VNID/LABEL	Nexthop IP	Encap
00:00:00:11:11:aa:aa:00:00:00	4294967295	37	17.17.17.17	MPLS

MH-2-7011#sh bgp l2vpn evpn

BGP table version is 8, local router ID is 11.11.11.11

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]

- 1 - Ethernet Auto-discovery Route
- 2 - MAC/IP Route
- 3 - Inclusive Multicast Route
- 4 - Ethernet Segment Route
- 5 - Prefix Route

Network Encap	Next Hop	Metric	LocPrf	Weight	Path	Peer
RD[10:400]						
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	17.17.17.17	0	100	0	?	17.17.17.17 MPLS
RD[30:400]						
*>i [5]:[0]:[0]:[24]:[40.40.1.0]:[0.0.0.0]:[16]	20.20.20.20	0	100	0	?	20.20.20.20 MPLS
RD[40:400]						
*>i [5]:[0]:[0]:[24]:[40.40.1.0]:[0.0.0.0]:[16]	22.22.22.22	0	100	0	?	22.22.22.22 MPLS
RD[11.11.11.11:400] VRF[green]:						
* i [2]:[0]:[400]:[48,0000:0000:aaaa]:[32,40.40.1.10]:[17]:[16]	20.20.20.20	0	100	0	i	20.20.20.20 MPLS
* i [2]:[0]:[400]:[48,0000:0000:bbbb]:[128,5001:aaaa::1]:[17]	20.20.20.20	0	100	0	i	20.20.20.20 MPLS
* i [2]:[0]:[400]:[48,0011:2233:5577]:[32,40.40.1.1]:[17]	22.22.22.22	0	100	0	i	22.22.22.22 MPLS
* i [2]:[0]:[400]:[48,0011:2233:5577]:[32,40.40.1.1]:[17]	20.20.20.20	0	100	0	i	20.20.20.20 MPLS
* i [2]:[0]:[400]:[48,0011:2233:5577]:[128,5001::1]:[17]	22.22.22.22	0	100	0	i	22.22.22.22 MPLS
* i [2]:[0]:[400]:[48,0011:2233:5577]:[128,5001::1]:[17]	20.20.20.20	0	100	0	i	20.20.20.20 MPLS
* i [2]:[0]:[500]:[48,0011:2233:5577]:[32,80.80.1.1]:[17]	17.17.17.17	0	100	0	i	17.17.17.17 MPLS
*> 11.11.11.11	11.11.11.11	0	100	32768	i	-----
MPLS						
*> [3]:[400]:[32,11.11.11.11]	11.11.11.11	0	100	32768	i	-----
MPLS						
* i [3]:[400]:[32,20.20.20.20]	20.20.20.20	0	100	0	i	20.20.20.20 MPLS
* i [3]:[400]:[32,22.22.22.22]	22.22.22.22	0	100	0	i	22.22.22.22 MPLS
*> [3]:[500]:[32,11.11.11.11]	11.11.11.11	0	100	32768	i	-----
MPLS						
* i [3]:[500]:[32,17.17.17.17]	17.17.17.17	0	100	0	i	17.17.17.17 MPLS
RD[11.11.11.11:64512] VRF[evpn-gvrf-1]:						
*> [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]	11.11.11.11	0	100	32768	i	-----
MPLS						
*> [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,11.11.11.11]	11.11.11.11	0	100	32768	i	-----
MPLS						
* i [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,17.17.17.17]						


```

17.17.17.17          0          100          0    i  17.17.17.17      MPLS

RD[17.17.17.17:400]
*>i  [2]:[0]:[500]:[48,0011:2233:5577]:[32,80.80.1.1]:[17]
17.17.17.17          0          100          0    i  17.17.17.17      MPLS
*>i  [3]:[500]:[32,17.17.17.17]
17.17.17.17          0          100          0    i  17.17.17.17      MPLS

RD[17.17.17.17:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
17.17.17.17          0          100          0    i  17.17.17.17      MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,17.17.17.17]
17.17.17.17          0          100          0    i  17.17.17.17      MPLS

RD[20.20.20.20:400]
*>i  [2]:[0]:[400]:[48,0000:0000:aaaa]:[32,40.40.1.10]:[17]:[16]
20.20.20.20          0          100          0    i  20.20.20.20      MPLS
*>i  [2]:[0]:[400]:[48,0000:0000:bbbb]:[128,5001:aaaa::1]:[17]
20.20.20.20          0          100          0    i  20.20.20.20      MPLS
*>i  [2]:[0]:[400]:[48,0011:2233:5577]:[32,40.40.1.1]:[17]
20.20.20.20          0          100          0    i  20.20.20.20      MPLS
*>i  [2]:[0]:[400]:[48,0011:2233:5577]:[128,5001::1]:[17]
20.20.20.20          0          100          0    i  20.20.20.20      MPLS
*>i  [3]:[400]:[32,20.20.20.20]
20.20.20.20          0          100          0    i  20.20.20.20      MPLS

RD[22.22.22.22:400]
*>i  [2]:[0]:[400]:[48,0011:2233:5577]:[32,40.40.1.1]:[17]
22.22.22.22          0          100          0    i  22.22.22.22      MPLS
*>i  [2]:[0]:[400]:[48,0011:2233:5577]:[128,5001::1]:[17]
22.22.22.22          0          100          0    i  22.22.22.22      MPLS
*>i  [3]:[400]:[32,22.22.22.22]
22.22.22.22          0          100          0    i  22.22.22.22      MPLS

```

PE4

MH-1-7017#show evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
17.17.17.17	22.22.22.22	Installed	1d00h04m	1d00h04m	40000
17.17.17.17	11.11.11.11	Installed	00:20:45	00:20:45	500
17.17.17.17	11.11.11.11	Installed	1d00h04m	1d00h04m	40000
17.17.17.17	20.20.20.20	Installed	1d00h04m	1d00h04m	40000

MH-1-7017#show evpn mpls arp-cache

MPLS-EVPN ARP-CACHE Information

=====

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
---------	---------	----------	------	---------	--------------

```
500      80.80.1.1      0011.2233.5577 Static Local  ----  
Total number of entries are 1
```

CHAPTER 3 EVPN Active-Standby

Overview

EVPN Multihoming is a mechanism that allows a host or customer edge (CE) device to be connected to multiple Provider Edge (PE) devices called Multihoming (MH) peers for redundancy and load balancing purposes. This provides high availability and resiliency to the network, ensuring continuous connectivity even in case of a PE device failure.

Note: OcNOS support extends to a maximum of two MH peers.

Multihoming supports two kinds of redundancy, namely 1. All Active 2. Active-Standby.

Till now, OcNOS support All-Active (A-A) only. In OcNOS version 6.4.1, Port-Active mode is supported and in OcNOS version 6.4.2, Single-Active mode is supported in the context of Active-Standby redundancy.

Single-Active

- In this mode, traffic for a specific host or MAC address is handled by only one of the PE devices (MH peers) at a time.
- The other PE devices remain in standby mode, ready to take over if the active PE fails.
- The physical link state (either Physical port or LACP port) on the standby PE remains up, enabling a faster transition to the active role in the event of a failover. The CE devices use different interfaces, including LACP or physical connections, to connect to the Peer MH devices.

Port-Active

- In this mode, traffic for a specific host or MAC address is handled by only one of the PE devices (MH peers) at a time.
- Each MH peer connects through LACP with the same key as the CE devices (similar to A-A redundancy).
- The physical link state (LACP port) on the standby PE is made down, effectively blocking traffic on those ports.
- If a failover occurs, the standby PE must bring up its LACP ports to start forwarding traffic.

IRB Active-Standby: Active-standby mode is also applicable to Integrated Routing and Bridging (IRB) for both L3VPN symmetric and asymmetric modes.

Feature Characteristics

Single-Active standby redundancy mechanisms support both ELAN and ELINE services.

Single-Active ELINE

ELINE refers to Ethernet Line services, where two PEs are cross-connected to each other over an Ethernet link.

In Single-Active ELINE, the primary objective is to achieve redundancy for hosts while also using the same link for data exchange until it fails, at which point it should switch to the secondary or standby link. Here's how it works:

- **MH Host Traffic**
 - One of the PE devices (MH peers) acts as the "Active" for the Attachment Circuit (AC) associated with the host. This PE sends and receives traffic to and from the host.
 - The other PE acts as the "Standby" for the same AC and does not allow traffic to or from the host.

- The standby PE, despite receiving BUM traffic from the Host device (which is unaware of the cross-connect), blocks this traffic at the standby PE itself, as it operates in a standby role for the AC. Conversely, the active PE allows the flow of traffic.
- **Remote Host Traffic:** Traffic originating from remote hosts destined for the multihomed host is only sent to the active MH peer for the corresponding AC. This ensures that the cross connect is established only with the Active MH peer.

Single-Active ELAN

ELAN stands for Ethernet LAN services, where a group of PEs are interconnected in a multipoint Ethernet network.

In Single-Active ELAN, similar to Single-Active ELINE, redundancy for hosts and data exchange over the primary link are priorities, but there are some specific differences for Ethernet LAN (ELAN) scenarios:

- **MH Host Traffic**
 - One of the PE devices (MH peers) is designated as the “Active” for the AC associated with the host. This PE handles sending and receiving traffic to and from remote locations.
 - The other PE acts as the “Standby” role for the same AC. It receives BUM traffic from the host but blocks the traffic. Additionally, it refrains from learning MAC addresses and does not uplift Address Resolution Protocol/ Neighbor Discovery (ARP/ND) packets.
 - Unicast traffic from the host will be directed to the active PE, which will then allow the traffic to be sent across the network.
- **Remote Host Unicast Traffic:** Unicast traffic from remote hosts destined for the multihomed host is sent only to the active MH peer for the corresponding AC. This is because the MAC addresses of the host are learned only from the Active MH peer.
- **Remote Host BUM Traffic:** BUM traffic, such as broadcast and multicast packets from the remote PE device, is replicated to both MH PEs. However, only the active PE, which is also designated as a forwarder, allows this traffic to reach the host. The standby PE, classified as a Non-Designated Forwarder, drops the egress traffic.

Port-Active Ethernet LAN (ELAN) and Ethernet LINE (ELINE) are examples of port-active standby redundancy mechanisms.

Port-Active ELINE

Port-Active ELINE enables redundancy and optimized data exchange by designating an active port for traffic handling in multihomed network setups. Here's how it works:

- **Active AC Link:** Among the Multihomed (MH) peers, a designated PE is assigned as “Active” for the AC associated with the host. This PE manages bidirectional traffic to and from the host. In a port-active configuration, all hosts associated with the ESI link remain in the same state, as the Active and Standby status is determined per ESI link.
- **Standby AC Link:** The AC link attached to the host, designated as “Standby,” remains operationally down. It serves as a backup link for failover scenarios.
- **MH Host traffic:** BUM and unicast traffic from the host are always directed towards the Active PE because the link towards the Active PE is operational UP. Conversely, the link towards the Standby PE from the host devices is operational DOWN.
- **Remote Host Traffic:** Traffic originating from remote hosts and destined for the multihomed host is directed exclusively to the Active MH node that serves the corresponding AC. This ensures efficient traffic routing and intelligent cross-connection establishment.

Port-Active ELAN

Port-Active ELAN enhances redundancy and efficient data exchange by designating an active port for traffic management in multihomed Ethernet LAN environments. Here's how it works:

- **Active AC Link:** Within the MH peers, one PE is identified as the “Active” entity for the AC. It manages traffic to and from remote locations efficiently.
- **Standby AC Link:** Similar to Port-Active ELINE, the standby AC link attached to the host remains operationally down to ensure effective standby redundancy.
- **MH Host Traffic:** In a port-active scenario, the standby link does not receive any traffic from the host. Only the active link manages incoming traffic from the host. The Active PE also learns and advertises host information to remote locations, including MAC addresses and ARP/ND details.
- **Remote Host Unicast Traffic:** Unicast traffic from remote sources is directed exclusively to the Active MH PE that has advertised the host address, optimizing traffic flow.
- **Remote Host BUM Traffic:** BUM traffic is replicated across all MH nodes. However, egress traffic for BUM packets occurs only from the Active PE. The standby PE drops the traffic since the AC links are operational DOWN.

Benefits

The benefits of Single-Active and Port-Active include enhanced redundancy and fault tolerance for hosts and customer edge devices, efficient data exchange, minimized downtime, and improved network resiliency in multihomed Ethernet Line and Ethernet LAN environments. These mechanisms ensure uninterrupted connectivity and optimized traffic management, contributing to higher availability and improved user experience.

Prerequisites

Here are the prerequisites for configuring EVPN Multihoming:

Ensure EVPN Configuration: Make sure that the EVPN is configured already in the network as it is a requirement for EVPN Multihoming.

Configure Attachment Circuits (AC): Ensure that each CE device is appropriately linked to the PE devices through Attachment Circuits. These circuits must be configured correctly.

Set Up LACP Configuration: To use Link Aggregation Control Protocol (LACP) for multihoming, configure LACP appropriately on the relevant interfaces.

EVPN MPLS Global Configuration: To enable EVPN MPLS features, need to configure global settings, such as enabling EVPN MPLS, defining global VTEP IP addresses, enabling hardware profile filtering for multihoming, and activating EVPN MPLS multihoming functionality. These settings are essential for EVPN and MPLS operation.

Access Port Configuration: Depending on the network's redundancy plan (single-active or port-active), configure access ports, including parameters for load balancing, service carving preferences, and EVPN settings. These configurations are crucial for network access and connectivity in an EVPN environment.

These prerequisites ensure that the network is ready for the implementation of EVPN Multihoming, providing redundancy and load balancing for CE devices.

Configuration

Here are sample configurations for [EVPN MPLS Active-Standby MultiHoming Configuration](#) and [EVPN SR Active-Standby Multi-Homing Configuration](#), including topology, configuration procedures, and corresponding validations.

For more information on the EVPN MPLS configurations, see the [EVPN MPLS Configuration](#) and [EVPN MPLS IRB Configuration](#) chapters in the *Multi-Protocol Label Switching Guide*.

EVPN MPLS Active-Standby MultiHoming Configuration

This section illustrates the Multi-Homed setup for the EVPN MPLS Active-Standby configuration, showcasing examples for both ELINE and ELAN services with LDP as the underlay MPLS path.

EVPN MPLS Active-Standby MH Topology

Figure 3-7 consists of customer edge routers CE1 and CE2, along with IPv4 Provider Edge routers PE1, PE2, PE3, and PE4, all interconnected through the core routers P1 and P2 in the IPv4 MPLS provider network.

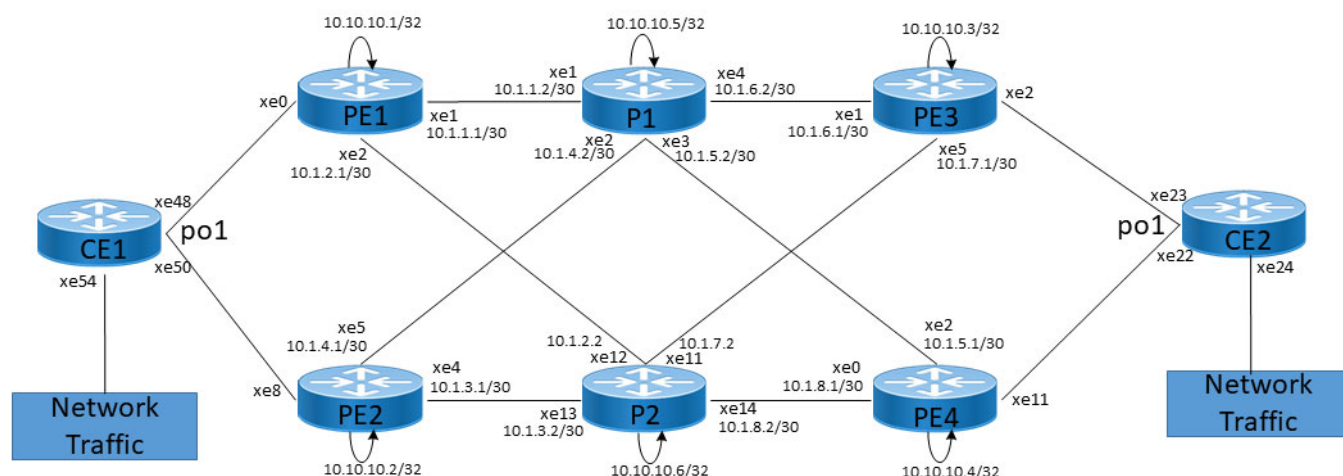


Figure 3-7: EVPN MPLS AS MH Configuration

CE1

The following configuration steps under CE1 are set up to enable VLANs and configure interfaces for carrying VLAN traffic.

CE1#configure terminal	Enter configure mode.
CE1(config)#bridge 1 protocol ieee vlan-bridge	Set up bridge 1 to use the IEEE VLAN bridge protocol.
CE1(config)#vlan 2-100 bridge 1 state enable	Configure VLANs from 2-100 and associate them with bridge 1.
CE1(config)#interface xe54	Enter interface mode xe54.
CE1(config-if)#switchport	Configure the interface xe54 as a Layer 2 switch port.
CE1(config-if)#bridge-group 1	Associate xe54 to bridge 1.
CE1(config-if)#switchport mode trunk	Configure xe54 as a trunk port.
CE1(config-if)#switchport trunk allowed vlan all	Allow all configured VLANs on the trunk interface xe54.
CE1(config-if)#exit	Exit interface mode xe54.
CE1(config)#interface po1	Enter interface mode and configure LAG interface port-channel 1 (po1).
CE1(config-if)#switchport	Configures port-channel 1 as a Layer 2 switch port.

CE1(config-if)#bridge-group 1	Associate po1 to bridge 1.
CE1(config-if)#switchport mode trunk	Configure po1 as a trunk port.
CE1(config-if)#switchport trunk allowed vlan all	Allow all configured VLANs on the trunk port-channel po1.
CE1(config-if)#exit	Exit interface mode po1.
CE1(config)#interface xe48	Enter interface mode xe48.
CE1(config-if)#lacp timeout short	Configure LACP timeout as short.
CE1(config-if)#channel-group 1 mode active	Add member to the LAG interface.
CE1(config-if)#exit	Exit interface mode xe48.
CE1(config-if)#interface xe50	Enter interface mode xe50.
CE1(config-if)#lacp timeout short	Configure LACP timeout as short.
CE1(config-if)#channel-group 1 mode active	Add member to the LAG interface.
CE1(config-if)#commit	Commit the transaction.
CE1(config-if)#end	Exit interface mode xe50 and configure mode.

PE1: Loopback Interface

The configuration on PE1 for a loopback interface with IP address 10.10.10.1/32 secondary is set up to provide IP connectivity for the router.

PE1#configure terminal	Enter configure mode.
PE1(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE1(config-if)#ip address 10.10.10.1/32 secondary	Configure a secondary IP address, 10.10.10.1/32, on the loopback interface.
PE1(config-if)#exit	Exit interface mode lo.
PE1(config)#commit	Commit the transaction.

PE1: Global LDP

The configuration on PE1 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE1(config)#router ldp	Enter the Router LDP mode.
PE1(config-router)#router-id 10.10.10.1	Set the router ID for LDP to 10.10.10.1.
PE1(config-router)#transport-address ipv4 10.10.10.1	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
PE1(config-router)#targeted-peer ipv4 10.10.10.2	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE1(config-router)#targeted-peer ipv4 10.10.10.3	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.

PE1(config-router)#targeted-peer ipv4 10.10.10.4	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE1(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: Global EVPN MPLS Command

The configuration on PE1 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE1(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE1, enabling it to participate in EVPN MPLS services.
PE1(config)#commit	Commit candidate configuration to be running configuration.
PE1(config)#evpn mpls vtep-ip-global 10.10.10.1	Configure the global VTEP IP address 10.10.10.1, associating it with the loopback IP.
PE1(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE1(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE1 to support multi-homed EVPN MPLS services.
PE1(config)#commit	Commit the transaction.

PE1: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE1 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE1(config)#interface xe1	Enter interface mode xe1.
PE1(config-if)#ip address 10.1.1.1/30	Configure an IP address, 10.1.1.1/30, on the interface xe1.
PE1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE1(config-if)#exit	Exit interface mode xe1.
PE1(config)#commit	Commit the transaction.
PE1(config)#interface xe2	Enter interface mode xe2.
PE1(config-if)#ip address 10.1.2.1/30	Configure an IP address, 10.1.2.1/30, on the interface xe2.
PE1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.

PE1(config-if)#exit	Exit interface mode xe2.
PE1(config)#commit	Commit the transaction.

PE1: OSPF Configuration

The below configuration is performed to set up OSPF on PE1, specifying the router ID, defining network interfaces, and configuring BFD parameters for efficient routing.

PE1(config)#router ospf 100	Enter the router OSPF mode. Configure PE1 to run OSPF with process ID 100.
PE1(config-router)#ospf router-id 10.10.10.1	Set the OSPF router ID to 10.10.10.1, identifying PE1 within the OSPF network.
PE1(config-router)#network 10.10.10.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
PE1(config-router)#network 10.1.1.1/30 area 0.0.0.0	Advertise network address in OSPF.
PE1(config-router)#network 10.1.2.1/30 area 0.0.0.0	Advertise network address in OSPF.
PE1(config-router)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval with an interval of 3, a minimum receive interval of 3, and a multiplier of 3.
PE1(config-router)#exit	Exit router OSPF mode and return to configure mode.
PE1(config)#commit	Commit the transaction.

PE1: BGP Configuration

The below BGP configuration on PE1 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

PE1(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
PE1(config-router)#bgp router-id 10.10.10.1	Configure BGP router ID 10.10.10.1, identifying PE1 within the BGP network.
PE1(config-router)#neighbor 10.10.10.2 remote-as 65010	Configure neighbor 10.10.10.2 as an iBGP neighbor with their remote AS number 65010.
PE1(config-router)#neighbor 10.10.10.2 update-source lo	Configure neighbor 10.10.10.2 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE1(config-router)#neighbor 10.10.10.3 remote-as 65010	Configure neighbor 10.10.10.3 as an iBGP neighbor with their remote AS number 65010.
PE1(config-router)#neighbor 10.10.10.3 update-source lo	Configure neighbor 10.10.10.3 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE1(config-router)#neighbor 10.10.10.4 remote-as 65010	Configure neighbor 10.10.10.4 as an iBGP neighbor with their remote AS number 65010.
PE1(config-router)#neighbor 10.10.10.4 update-source lo	Configure neighbor 10.10.10.4 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE1(config-router)#neighbor 10.10.10.2 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.

PE1(config-router)#neighbor 10.10.10.3 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE1(config-router)#neighbor 10.10.10.4 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE1(config-router)#neighbor 10.10.10.2 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE1(config-router)#neighbor 10.10.10.3 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE1(config-router)#neighbor 10.10.10.4 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE1(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE1(config-router-af)#neighbor 10.10.10.2 activate	Activate EVPN for iBGP neighbor 10.10.10.2 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE1(config-router-af)#neighbor 10.10.10.3 activate	Activate EVPN for iBGP neighbor 10.10.10.3 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE1(config-router-af)#neighbor 10.10.10.4 activate	Activate EVPN for iBGP neighbor 10.10.10.4 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE1(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE1(config-router)#commit	Commit the transaction.
PE1(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE1: MAC VRF Configuration

The below MAC VRF configuration on PE1 is carried out to define and set up VRFs named `vrf2` and `vpls1001` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE1(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE1(config-vrf)#rd 10.10.10.1:1700	Configure Route-Distinguisher value of 10.10.10.1:1700.
PE1(config-vrf)#route-target both 1700:1700	Configure import and export values for the vrf2 as 1700:1700.
PE1(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE1(config)#mac vrf vpls1001	Enter VRF mode named vpls1001.
PE1(config-vrf)#rd 10.10.10.1:1001	Configure Route-Distinguisher value of 10.10.10.1:1001.
PE1(config-vrf)#route-target both 1001:1001	Configure import and export values for the vpls1001 as 1001:1001.
PE1(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE1 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

PE1(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with a source identifier of 1800 and a target identifier of 1700.
PE1(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE1(config-evpn-mpls)#commit	Commit the transaction.
PE1(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
PE1(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier an identifier of 3000.
PE1(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Map VRF vpls1001 to the EVPN-VPWS identifier
PE1(config-evpn-mpls)#commit	Commit the transaction.
PE1(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE1 is carried out to configure various parameters including system-mac, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

PE1(config)#interface po1	Enter the port channel interface mode for po1
PE1(config-if)#load-interval 30	Set the load interval to 30.
PE1(config-if)#evpn multi-homed system-mac 0000.1111.7777 load-balancing port-active	Configure the system-mac address 0000.1111.7777 for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE1(config-if-es)#service-carving auto	Configure service carving as auto.
PE1(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE1(config-if)#exit	Exit interface mode po1 and return to the configure mode.
PE1(config)#commit	Commit the transaction.
PE1(config)#interface po1.1 switchport	Create a Layer 2 sub-interface po1.1 within the port channel.
PE1(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE1(config-if)#load-interval 30	Set the load interval to 30.
PE1(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE1(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE1(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE1(config-if)#exit	Exit interface mode po1.1 and return to the configure mode.
PE1(config)#interface xe0	Enter the interface mode for xe0.
PE1(config-if)#speed 10g	Set the speed to 10g.
PE1(config-if)#channel-group 1 mode active	Attach LAG interface po1.
PE1(config-if)#exit	Exit interface mode xe0 and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE1 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

PE1(config)#interface sa1	Enter the single active interface mode for sa1
PE1(config-if)#load-interval 30	Set the load interval to 30.
PE1(config-if)#evpn multi-homed esi 00:00:11:11:77:77 load-balancing single-active	Configure the ESI with the value with the value 00:00:11:11:77:77 for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE1(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE1(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE1(config-if)#exit	Exit interface mode sa1 and return to the configure mode.
PE1(config)#commit	Commit the transaction.
PE1(config)#interface sa1.1 switchport	Create a Layer 2 sub-interface sa1.1 within the port channel.
PE1(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE1(config-if)#load-interval 30	Set the load interval to 30.
PE1(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE1(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE1(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE1(config-if)#exit	Exit interface mode sa1.1 and return to the configure mode.
PE1(config)#interface xe0	Enter the interface mode for xe0.
PE1(config-if)#speed 10g	Set the speed to 10g.
PE1(config-if)#static-channel-group 1	Attach the static-channel-group 1, the LAG interface sa1 to xe0.
PE1(config-if)#exit	Exit interface mode xe0 and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE2: Loopback Interface

The configuration on PE2 for a loopback interface with IP address 10.10.10.2/32 secondary is set up to provide IP connectivity for the router.

PE2#configure terminal	Enter configure mode.
PE2(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE2(config-if)#ip address 10.10.10.2/32 secondary	Configure a secondary IP address, 10.10.10.2/32, on the loopback interface.
PE2(config-if)#exit	Exit interface mode lo.
PE2(config)#commit	Commit the transaction.

PE2: Global LDP

The configuration on PE2 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE2(config)#router ldp	Enter the Router LDP mode.
PE2(config-router)#router-id 10.10.10.2	Set the router ID for LDP to 10.10.10.2.
PE2(config-router)#transport-address ipv4 10.10.10.2	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
PE2(config-router)#targeted-peer ipv4 10.10.10.1	Configure targeted peer for LDP using IPv4 addresses.
PE2(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE2(config-router)#targeted-peer ipv4 10.10.10.3	Configure targeted peer for LDP using IPv4 addresses.
PE2(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE2(config-router)#targeted-peer ipv4 10.10.10.4	Configure targeted peer for LDP using IPv4 addresses.
PE2(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE2(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE2: Global EVPN MPLS Command

The configuration on PE2 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE2(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE2, enabling it to participate in EVPN MPLS services.
PE2(config)#commit	Commit candidate configuration to be running configuration.
PE2(config)#evpn mpls vtep-ip-global 10.10.10.2	Configure the global VTEP IP address 10.10.10.2, associating it with the loopback IP.
PE2(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE2(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE2 to support multi-homed EVPN MPLS services.
PE2(config)#commit	Commit the transaction.

PE2: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE2 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE2(config)#interface xe4	Enter interface mode xe4.
PE2(config-if)#ip address 10.1.3.1/30	Configure an IP address, 10.1.3.1/30, on the interface xe4.
PE2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE2(config-if)#exit	Exit interface mode xe4.
PE2(config)#commit	Commit the transaction.
PE2(config)#interface xe5	Enter interface mode xe5.
PE2(config-if)#ip address 10.1.4.1/30	Configure an IP address, 10.1.4.1/30, on the interface xe5.
PE2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE2(config-if)#exit	Exit interface mode xe5.
PE2(config)#commit	Commit the transaction.

PE2: OSPF Configuration

The below configuration is performed to set up OSPF on PE2, specifying the router ID, defining network interfaces, and configuring BFD parameters for efficient routing.

PE2(config)#router ospf 100	Enter the router OSPF mode. Configure PE2 to run OSPF with process ID 100.
PE2(config-router)#ospf router-id 10.10.10.2	Set the OSPF router ID to 10.10.10.2, identifying PE2 within the OSPF network.
PE2(config-router)#network 10.1.3.1/30 area 0.0.0.0	Advertise loopback address in OSPF.
PE2(config-router)#network 10.1.4.1/30 area 0.0.0.0	Advertise network address in OSPF.
PE2(config-router)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval with an interval of 3, a minimum receive interval of 3, and a multiplier of 3.
PE2(config-router)#exit	Exit router OSPF mode and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE2: BGP Configuration

The below BGP configuration on PE2 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

PE2(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
PE2(config-router)#bgp router-id 10.10.10.2	Configure BGP router ID 10.10.10.2, identifying PE2 within the BGP network.

PE2(config-router)#neighbor 10.10.10.1 remote-as 65010	Configure neighbor 10.10.10.1 as an iBGP neighbor with their remote AS number 65010.
PE2(config-router)#neighbor 10.10.10.1 update-source lo	Configure neighbor 10.10.10.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE2(config-router)#neighbor 10.10.10.3 remote-as 65010	Configure neighbor 10.10.10.3 as an iBGP neighbor with their remote AS number 65010.
PE2(config-router)#neighbor 10.10.10.3 update-source lo	Configure neighbor 10.10.10.3 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE2(config-router)#neighbor 10.10.10.4 remote-as 65010	Configure neighbor 10.10.10.4 as an iBGP neighbor with their remote AS number 65010.
PE2(config-router)#neighbor 10.10.10.4 update-source lo	Configure neighbor 10.10.10.4 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE2(config-router)#neighbor 10.10.10.1 fall- over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE2(config-router)#neighbor 10.10.10.3 fall- over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE2(config-router)#neighbor 10.10.10.4 fall- over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE2(config-router)#neighbor 10.10.10.1 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE2(config-router)#neighbor 10.10.10.3 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE2(config-router)#neighbor 10.10.10.4 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE2(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE2(config-router-af)#neighbor 10.10.10.1 activate	Activate EVPN for iBGP neighbor 10.10.10.1 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE2(config-router-af)#neighbor 10.10.10.3 activate	Activate EVPN for iBGP neighbor 10.10.10.3 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE2(config-router-af)#neighbor 10.10.10.4 activate	Activate EVPN for iBGP neighbor 10.10.10.4 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE2(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE2(config-router)#commit	Commit the transaction.
PE2(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE2: MAC VRF Configuration

The below MAC VRF configuration on PE2 is carried out to define and set up VRFs named `vrf2` and `vp1s1001` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE2(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE2(config-vrf)#rd 10.10.10.2:1700	Configure Route-Distinguisher value of 10.10.10.2:1700.
PE2(config-vrf)#route-target both 1700:1700	Configure import and export values for the vrf2 as 1700:1700.
PE2(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE2(config)#mac vrf vpls1001	Enter VRF mode named vpls1001.
PE2(config-vrf)#rd 10.10.10.2:1001	Configure Route-Distinguisher value of 10.10.10.2:1001.
PE2(config-vrf)#route-target both 1001:1001	Configure import and export values for the vpls1001 as 1001:1001.
PE2(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE2: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE2 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

PE2(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with a source identifier of 1800 and a target identifier of 1700.
PE2(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE2(config-evpn-mpls)#commit	Commit the transaction.
PE2(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
PE2(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier an identifier of 3000.
PE2(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Map VRF vpls1001 to the EVPN-VPWS identifier
PE2(config-evpn-mpls)#commit	Commit the transaction.
PE2(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE2 is carried out to configure various parameters including system-mac, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

PE2(config)#interface po1	Enter the port channel interface mode for po1
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#evpn multi-homed system-mac 0000.1111.7777 load-balancing port-active	Configure the system-mac address 0000.1111.7777 for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE2(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE2(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE2(config-if)#exit	Exit interface mode po1 and return to the configure mode.

PE2(config)#commit	Commit the transaction.
PE2(config)#interface po1.1 switchport	Create a Layer 2 sub-interface po1.1 within the port channel.
PE2(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE2(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE2(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE2(config-if)#exit	Exit interface mode po1.1 and return to the configure mode.
PE2(config)#interface xe08	Enter the interface mode for xe8.
PE2(config-if)#speed 10g	Set the speed to 10g.
PE2(config-if)#channel-group 1 mode active	Attach LAG interface po1.
PE2(config-if)#exit	Exit interface mode xe8 and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE2: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE2 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

PE2(config)#interface sa2	Enter the single active interface mode for sa2.
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#evpn multi-homed esi 00:00:11:11:77:77 load-balancing single-active	Configure the ESI with the value 00:00:11:11:77:77 for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE2(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE2(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE2(config-if)#exit	Exit interface mode sa2 and return to the configure mode.
PE2(config)#commit	Commit the transaction.
PE2(config)#interface sa2.1 switchport	Create a Layer 2 sub-interface sa2.1 within the port channel.
PE2(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE2(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE2(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE2(config-if)#exit	Exit interface mode sa2.1 and return to the configure mode.
PE2(config)#interface xe8	Enter the interface mode for xe8.
PE2(config-if)#speed 10g	Set the speed to 10g.
PE2(config-if)#static-channel-group 2	Attach the static-channel-group 2, the LAG interface sa2 to xe8.

PE2(config-if)#exit	Exit interface mode xe8 and return to the configure mode.
PE2(config)#commit	Commit the transaction.

P1: Loopback Interface

The configuration on P1 for a loopback interface with IP address 10.10.10.5/32 secondary is set up to provide IP connectivity for the router.

P1#configure terminal	Enter configure mode.
P1(config)#interface lo	Enter the interface mode for the loopback interface lo.
P1(config-if)#ip address 10.10.10.5/32 secondary	Configure a secondary IP address, 10.10.10.5/32, on the loopback interface.
P1(config-if)#exit	Exit interface mode lo.
P1(config)#commit	Commit the transaction.

P1: Global LDP

The configuration on P1 for the Global LDP router, specifying router ID and targeted peer, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

P1(config)#router ldp	Enter the Router LDP mode.
P1(config-router)#router-id 10.10.10.5	Set the router ID for LDP to 10.10.10.5.
P1(config-router)#transport-address ipv4 10.10.10.5	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
P1(config-router)#exit	Exit router LDP mode and return to the configure mode.
P1(config)#commit	Commit the transaction.

P1: Interface Configuration

The below configuration is performed to set up interfaces on P1 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

P1(config)#interface xe1	Enter interface mode xe1.
P1(config-if)#ip address 10.1.1.2/30	Configure an IP address, 10.1.1.2/30, on the interface xe1.
P1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P1(config-if)#exit	Exit interface mode xe1.
P1(config)#commit	Commit the transaction.
P1(config)#interface xe2	Enter interface mode xe2.
P1(config-if)#ip address 10.1.4.2/30	Configure an IP address, 10.1.4.2/30, on the interface xe2.

P1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P1(config-if)#exit	Exit interface mode xe2.
P1(config)#commit	Commit the transaction.
P1(config)#interface xe3	Enter interface mode xe3.
P1(config-if)#ip address 10.1.5.2/30	Configure an IP address, 10.1.5.2/30, on the interface xe3.
P1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P1(config-if)#exit	Exit interface mode xe3.
P1(config)#commit	Commit the transaction.
P1(config)#interface xe4	Enter interface mode xe4.
P1(config-if)#ip address 10.1.6.2/30	Configure an IP address, 10.1.6.2/30, on the interface xe4.
P1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P1(config-if)#exit	Exit interface mode xe4.
P1(config)#commit	Commit the transaction.

P1: OSPF Configuration

The below configuration is performed to set up OSPF on P1, specifying the router ID, and defining network interfaces for efficient routing.

P1(config)#router ospf 100	Enter the router OSPF mode. Configure P1 to run OSPF with process ID 100.
P1(config-router)#ospf router-id 10.10.10.5	Set the OSPF router ID to 10.10.10.5, identifying P1 within the OSPF network.
P1(config-router)#network 10.10.10.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
P1(config-router)#network 10.1.1.2/30 area 0.0.0.0	Advertise network address in OSPF.
P1(config-router)#network 10.1.4.2/30 area 0.0.0.0	Advertise network address in OSPF.
P1(config-router)#network 10.1.5.2/30 area 0.0.0.0	Advertise network address in OSPF.
P1(config-router)#network 10.1.6.2/30 area 0.0.0.0	Advertise network address in OSPF.

P1(config-router)#exit	Exit router OSPF mode and return to the configure mode.
P1(config)#commit	Commit the transaction.

P2: Loopback Interface

The configuration on P2 for a loopback interface with IP address 10.10.10.6/32 secondary is set up to provide IP connectivity for the router.

P2#configure terminal	Enter configure mode.
P2(config)#interface lo	Enter the interface mode for the loopback interface lo.
P2(config-if)#ip address 10.10.10.6/32 secondary	Configure a secondary IP address, 10.10.10.6/32, on the loopback interface.
P2(config-if)#exit	Exit interface mode lo.
P2(config)#commit	Commit the transaction.

P2: Global LDP

The configuration on P2 for the Global LDP router, specifying router ID and targeted peer, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

P2(config)#router ldp	Enter the Router LDP mode.
P2(config-router)#router-id 10.10.10.6	Set the router ID for LDP to 10.10.10.6.
P2(config-router)#transport-address ipv4 10.10.10.6	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
P2(config-router)#exit	Exit router LDP mode and return to the configure mode.
P2(config)#commit	Commit the transaction.

P2: Interface Configuration

The below configuration is performed to set up interfaces on P2 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

P2(config)#interface xe12	Enter interface mode xe12.
P2(config-if)#ip address 10.1.2.2/30	Configure an IP address, 10.1.2.2/30, on the interface xe12.
P2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P2(config-if)#exit	Exit interface mode xe12.
P2(config)#commit	Commit the transaction.
P2(config)#interface xe13	Enter interface mode xe13.
P2(config-if)#ip address 10.1.3.2/30	Configure an IP address, 10.1.3.2/30, on the interface xe13.

P2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P2(config-if)#exit	Exit interface mode xe13.
P2(config)#commit	Commit the transaction.
P2(config)#interface xe11	Enter interface mode xe11.
P2(config-if)#ip address 10.1.7.2/30	Configure an IP address, 10.1.7.2/30, on the interface xe11.
P2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P2(config-if)#exit	Exit interface mode xe11.
P2(config)#commit	Commit the transaction.
P2(config)#interface xe14	Enter interface mode xe14.
P2(config-if)#ip address 10.1.8.2/30	Configure an IP address, 10.1.8.2/30, on the interface xe14.
P2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P2(config-if)#exit	Exit interface mode xe14.
P2(config)#commit	Commit the transaction.

P2: OSPF Configuration

The below configuration is performed to set up OSPF on P2, specifying the router ID, and defining network interfaces for efficient routing.

P2(config)#router ospf 100	Enter the router OSPF mode. Configure P2 to run OSPF with process ID 100.
P2(config-router)#ospf router-id 10.10.10.6	Set the OSPF router ID to 10.10.10.6, identifying P2 within the OSPF network.
P2(config-router)#network 10.10.10.6/32 area 0.0.0.0	Advertise loopback address in OSPF.
P2(config-router)#network 10.1.2.2/30 area 0.0.0.0	Advertise network address in OSPF.
P2(config-router)#network 10.1.3.2/30 area 0.0.0.0	Advertise network address in OSPF.
P2(config-router)#network 10.1.7.2/30 area 0.0.0.0	Advertise network address in OSPF.
P2(config-router)#network 10.1.8.2/30 area 0.0.0.0	Advertise network address in OSPF.

P2(config-router)#exit	Exit router OSPF mode and return to the configure mode.
P2(config)#commit	Commit the transaction.

PE3: Loopback Interface

The configuration on PE3 for a loopback interface with IP address 10.10.10.3/32 secondary is set up to provide IP connectivity for the router.

PE3#configure terminal	Enter configure mode.
PE3(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE3(config-if)#ip address 10.10.10.3/32 secondary	Configure a secondary IP address, 10.10.10.3/32, on the loopback interface.
PE3(config-if)#exit	Exit interface mode lo.
PE3(config)#commit	Commit the transaction.

PE3: Global LDP

The configuration on PE3 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE3(config)#router ldp	Enter the Router LDP mode.
PE3(config-router)#router-id 10.10.10.3	Set the router ID for LDP to 10.10.10.3.
PE2(config-router)#transport-address ipv4 10.10.10.3	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
PE3(config-router)#targeted-peer ipv4 10.10.10.1	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#targeted-peer ipv4 10.10.10.2	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#targeted-peer ipv4 10.10.10.4	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: Global EVPN MPLS Command

The configuration on PE3 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE3(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE3, enabling it to participate in EVPN MPLS services.
PE3(config)#commit	Commit candidate configuration to be running configuration.
PE3(config)#evpn mpls vtep-ip-global 10.10.10.3	Configure the global VTEP IP address 10.10.10.3, associating it with the loopback IP.
PE3(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE3(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE3 to support multi-homed EVPN MPLS services.
PE3(config)#commit	Commit the transaction.

PE3: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE3 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE3(config)#interface xe1	Enter interface mode xe1.
PE3(config-if)#ip address 10.1.6.1/30	Configure an IP address, 10.1.6.1/30, on the interface xe1.
PE3(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE3(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE3(config-if)#exit	Exit interface mode xe1.
PE3(config)#commit	Commit the transaction.
PE3(config)#interface xe5	Enter interface mode xe5.
PE3(config-if)#ip address 10.1.7.1/30	Configure an IP address, 10.1.7.1/30, on the interface xe5.
PE3(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE3(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE3(config-if)#exit	Exit interface mode xe5.
PE3(config)#commit	Commit the transaction.

PE3: OSPF Configuration

The below configuration is performed to set up OSPF on PE3, specifying the router ID, defining network interfaces, and configuring BFD parameters for efficient routing.

PE3(config)#router ospf 100	Enter the router OSPF mode. Configure PE3 to run OSPF with process ID 100.
PE3(config-router)#ospf router-id 10.10.10.3	Set the OSPF router ID to 10.10.10.3, identifying PE3 within the OSPF network.
PE3(config-router)#network 10.10.10.3/32 area 0.0.0.0	Advertise loopback address in OSPF.

PE3(config-router)#network 10.1.6.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
PE3(config-router)#network 10.1.7.1/30 area 0.0.0.0	Advertise network address in OSPF.
PE3(config-router)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval with an interval of 3, a minimum receive interval of 3, and a multiplier of 3.
PE3(config-router)#exit	Exit router OSPF mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: BGP Configuration

The below BGP configuration on PE3 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

PE3(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
PE3(config-router)#bgp router-id 10.10.10.3	Configure BGP router ID 10.10.10.2, identifying PE3 within the BGP network.
PE3(config-router)#neighbor 10.10.10.1 remote-as 65010	Configure neighbor 10.10.10.1 as an iBGP neighbor with their remote AS number 65010.
PE3(config-router)#neighbor 10.10.10.1 update-source lo	Configure neighbor 10.10.10.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 10.10.10.2 remote-as 65010	Configure neighbor 10.10.10.2 as an iBGP neighbor with their remote AS number 65010.
PE3(config-router)#neighbor 10.10.10.2 update-source lo	Configure neighbor 10.10.10.2 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 10.10.10.4 remote-as 65010	Configure neighbor 10.10.10.4 as an iBGP neighbor with their remote AS number 65010.
PE3(config-router)#neighbor 10.10.10.4 update-source lo	Configure neighbor 10.10.10.4 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 10.10.10.1 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE3(config-router)#neighbor 10.10.10.2 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE3(config-router)#neighbor 10.10.10.4 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE3(config-router)#neighbor 10.10.10.1 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE3(config-router)#neighbor 10.10.10.2 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE3(config-router)#neighbor 10.10.10.4 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE3(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE3(config-router-af)#neighbor 10.10.10.1 activate	Activate EVPN for iBGP neighbor 10.10.10.1 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.

PE3(config-router-af)#neighbor 10.10.10.2 activate	Activate EVPN for iBGP neighbor 10.10.10.2 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#neighbor 10.10.10.4 activate	Activate EVPN for iBGP neighbor 10.10.10.4 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE3(config-router)#commit	Commit the transaction.
PE3(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE3: MAC VRF Configuration

The below MAC VRF configuration on PE3 is carried out to define and set up VRFs named `vrf2` and `vpls1001` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE3(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE3(config-vrf)#rd 10.10.10.3:1700	Configure Route-Distinguisher value of 10.10.10.3:1700.
PE3(config-vrf)#route-target both 1700:1700	Configure import and export values for the vrf2 as 1700:1700.
PE3(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE3(config)#mac vrf vpls1001	Enter VRF mode named vpls1001.
PE3(config-vrf)#rd 10.10.10.3:1001	Configure Route-Distinguisher value of 10.10.10.3:1001.
PE3(config-vrf)#route-target both 1001:1001	Configure import and export values for the vpls1001 as 1001:1001.
PE3(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE3 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

PE3(config)#evpn mpls id 1700 xconnect target-mpls-id 1800	Configure the EVPN-VPWS identifier with a source identifier of 1700 and a target identifier of 1800.
PE3(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE3(config-evpn-mpls)#commit	Commit the transaction.
PE3(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
PE3(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier an identifier of 3000.
PE3(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Map VRF vpls1001 to the EVPN-VPWS identifier
PE3(config-evpn-mpls)#commit	Commit the transaction.
PE3(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE3: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE3 is carried out to configure various parameters including system-MAC, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

PE3(config)#interface po1	Enter the port channel interface mode for po1
PE3(config-if)#load-interval 30	Set the load interval to 30.
PE3(config-if)#evpn multi-homed system-mac 0000.2222.7777 load-balancing port-active	Configure the system-mac address 0000.2222.7777 for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE3(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE3(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE3(config-if)#exit	Exit interface mode po1 and return to the configure mode.
PE3(config)#commit	Commit the transaction.
PE3(config)#interface po1.1 switchport	Create a Layer 2 sub-interface po1.1 within the port channel.
PE3(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE3(config-if)#load-interval 30	Set the load interval to 30.
PE3(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE3(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE3(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE3(config-if)#exit	Exit interface mode po1.1 and return to the configure mode.
PE3(config)#interface xe2	Enter the interface mode for xe2.
PE3(config-if)#speed 10g	Set the speed to 10g.
PE3(config-if)#channel-group 1 mode active	Attach LAG interface po1.
PE3(config-if)#exit	Exit interface mode xe2 and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE3 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

PE3(config)#interface sa1	Enter the single active interface mode for sa1.
PE3(config-if)#load-interval 30	Set the load interval to 30.
PE3(config-if)#evpn multi-homed esi 00:00:22:22:77:77 load-balancing single-active	Configure the ESI with the value with the value 00:00:22:22:77:77 for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE3(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE3(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE3(config-if)#exit	Exit interface mode sa1 and return to the configure mode.

PE3(config)#commit	Commit the transaction.
PE3(config)#interface sa1.1 switchport	Create a Layer 2 sub-interface sa1.1 within the port channel.
PE3(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE3(config-if)#load-interval 30	Set the load interval to 30.
PE3(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE3(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE3(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE3(config-if)#exit	Exit interface mode sa1.1 and return to the configure mode.
PE3(config)#interface xe2	Enter the interface mode for xe2.
PE3(config-if)#speed 10g	Set the speed to 10g.
PE3(config-if)#static-channel-group 1	Attach the static-channel-group 1, the LAG interface sa1 to xe2.
PE3(config-if)#exit	Exit interface mode xe2 and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE4: Loopback Interface

The configuration on PE4 for a loopback interface with IP address 10.10.10.4/32 secondary is set up to provide IP connectivity for the router.

PE4#configure terminal	Enter configure mode.
PE4(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE4(config-if)#ip address 10.10.10.4/32 secondary	Configure a secondary IP address, 10.10.10.4/32, on the loopback interface.
PE4(config-if)#exit	Exit interface mode lo.
PE4(config)#commit	Commit the transaction.

PE4: Global LDP

The configuration on PE4 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE4(config)#router ldp	Enter the Router LDP mode.
PE4(config-router)#router-id 10.10.10.4	Set the router ID for LDP to 10.10.10.4.
PE4(config-router)#transport-address ipv4 10.10.10.4	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
PE4(config-router)#targeted-peer ipv4 10.10.10.1	Configure targeted peer for LDP using IPv4 addresses.
PE4(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE4(config-router)#targeted-peer ipv4 10.10.10.2	Configure targeted peer for LDP using IPv4 addresses.

PE4(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE4(config-router)#targeted-peer ipv4 10.10.10.3	Configure targeted peer for LDP using IPv4 addresses.
PE4(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE4(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE4(config)#commit	Commit the transaction.

PE4: Global EVPN MPLS Command

The configuration on PE4 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE4(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE4, enabling it to participate in EVPN MPLS services.
PE4(config)#commit	Commit candidate configuration to be running configuration.
PE4(config)#evpn mpls vtep-ip-global 10.10.10.4	Configure the global VTEP IP address 10.10.10.4, associating it with the loopback IP.
PE4(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE4(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE4 to support multi-homed EVPN MPLS services.
PE4(config)#commit	Commit the transaction.

PE4: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE4 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE4(config)#interface xe2	Enter interface mode xe2.
PE4(config-if)#ip address 10.1.5.1/30	Configure an IP address, 10.1.5.1/30, on the interface xe2.
PE4(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE4(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE4(config-if)#exit	Exit interface mode xe2.
PE4(config)#commit	Commit the transaction.
PE4(config)#interface xe0	Enter interface mode xe0.
PE4(config-if)#ip address 10.1.8.1/30	Configure an IP address, 10.1.8.1/30, on the interface xe0.
PE4(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE4(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.

PE4(config-if)#exit	Exit interface mode <code>xe0</code> .
PE4(config)#commit	Commit the transaction.

PE4: OSPF Configuration

The below configuration is performed to set up OSPF on PE4, specifying the router ID, defining network interfaces, and configuring BFD parameters for efficient routing.

PE4(config)#router ospf 100	Enter the router OSPF mode. Configure PE4 to run OSPF with process ID 100.
PE4(config-router)#ospf router-id 10.10.10.4	Set the OSPF router ID to 10.10.10.4, identifying PE3 within the OSPF network.
PE4(config-router)#network 10.10.10.4/32 area 0.0.0.0	Advertise loopback address in OSPF.
PE4(config-router)#network 10.1.5.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
PE4(config-router)#network 10.1.8.1/30 area 0.0.0.0	Advertise network address in OSPF.
PE4(config-router)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval with an interval of 3, a minimum receive interval of 3, and a multiplier of 3.
PE4(config-router)#exit	Exit router OSPF mode and return to the configure mode.
PE4(config)#commit	Commit the transaction.

PE4: BGP Configuration

The below BGP configuration on PE4 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

PE4(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
PE4(config-router)#bgp router-id 10.10.10.4	Configure BGP router ID 10.10.10.4, identifying PE4 within the BGP network.
PE4(config-router)#neighbor 10.10.10.1 remote-as 65010	Configure neighbor 10.10.10.1 as an iBGP neighbor with their remote AS number 65010.
PE4(config-router)#neighbor 10.10.10.1 update-source lo	Configure neighbor 10.10.10.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE4(config-router)#neighbor 10.10.10.2 remote-as 65010	Configure neighbor 10.10.10.2 as an iBGP neighbor with their remote AS number 65010.
PE4(config-router)#neighbor 10.10.10.2 update-source lo	Configure neighbor 10.10.10.2 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE4(config-router)#neighbor 10.10.10.3 remote-as 65010	Configure neighbor 10.10.10.3 as an iBGP neighbor with their remote AS number 65010.
PE4(config-router)#neighbor 10.10.10.3 update-source lo	Configure neighbor 10.10.10.3 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE4(config-router)#neighbor 10.10.10.1 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.

PE4(config-router)#neighbor 10.10.10.2 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE4(config-router)#neighbor 10.10.10.3 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE4(config-router)#neighbor 10.10.10.1 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE4(config-router)#neighbor 10.10.10.2 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE4(config-router)#neighbor 10.10.10.3 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE4(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE4(config-router-af)#neighbor 10.10.10.1 activate	Activate EVPN for iBGP neighbor 10.10.10.1 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE4(config-router-af)#neighbor 10.10.10.2 activate	Activate EVPN for iBGP neighbor 10.10.10.2 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE4(config-router-af)#neighbor 10.10.10.3 activate	Activate EVPN for iBGP neighbor 10.10.10.3 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE4(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE4(config-router)#commit	Commit the transaction.
PE4(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE4: MAC VRF Configuration

The below MAC VRF configuration on PE4 is carried out to define and set up VRFs named `vrf2` and `vpls1001` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE4(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE4(config-vrf)#rd 10.10.10.4:1700	Configure Route-Distinguisher value of 10.10.10.4:1700.
PE4(config-vrf)#route-target both 1700:1700	Configure import and export values for the vrf2 as 1700:1700.
PE4(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE4(config)#mac vrf vpls1001	Enter VRF mode named vpls1001.
PE4(config-vrf)#rd 10.10.10.4:1001	Configure Route-Distinguisher value of 10.10.10.4:1001.
PE4(config-vrf)#route-target both 1001:1001	Configure import and export values for the vpls1001 as 1001:1001.
PE4(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE4(config)#commit	Commit the transaction.

PE4: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE4 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

PE4(config)#evpn mpls id 1700 xconnect target-mpls-id 1800	Configure the EVPN-VPWS identifier with a source identifier of 1700 and a target identifier of 1800.
PE4(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE4(config-evpn-mpls)#commit	Commit the transaction.
PE4(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
PE4(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier an identifier of 3000.
PE4(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Map VRF vpls1001 to the EVPN-VPWS identifier
PE4(config-evpn-mpls)#commit	Commit the transaction.
PE4(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE4: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE4 is carried out to configure various parameters including system-MAC, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

PE4(config)#interface po1	Enter the port channel interface mode for po1
PE4(config-if)#load-interval 30	Set the load interval to 30.
PE4(config-if)#evpn multi-homed system-mac 0000.2222.7777 load-balancing port-active	Configure the system-mac address 0000.2222.7777 for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE4(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE4(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE4(config-if)#exit	Exit interface mode po1 and return to the configure mode.
PE4(config)#commit	Commit the transaction.
PE4(config)#interface po1.1 switchport	Create a Layer 2 sub-interface po1.1 within the port channel.
PE4(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE4(config-if)#load-interval 30	Set the load interval to 30.
PE4(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE4(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE4(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE4(config-if)#exit	Exit interface mode po1.1 and return to the configure mode.
PE4(config)#interface xe11	Enter the interface mode for xe11.
PE4(config-if)#speed 10g	Set the speed to 10g.
PE4(config-if)#channel-group 1 mode active	Attach LAG interface po1.
PE4(config-if)#exit	Exit interface mode xe11 and return to the configure mode.
PE4(config)#commit	Commit the transaction.

PE4: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE4 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

PE4(config)#interface sa2	Enter the single active interface mode for sa2.
PE4(config-if)#load-interval 30	Set the load interval to 30.
PE4(config-if)#evpn multi-homed esi 00:00:22:22:77:77 load-balancing single-active	Configure the ESI with the value with the value 00:00:22:22:77:77 for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE4(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE4(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE4(config-if)#exit	Exit interface mode sa2 and return to the configure mode.
PE4(config)#commit	Commit the transaction.
PE4(config)#interface sa2.1 switchport	Create a Layer 2 sub-interface sa2.1 within the port channel.
PE4(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE4(config-if)#load-interval 30	Set the load interval to 30.
PE4(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE4(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE4(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE4(config-if)#exit	Exit interface mode sa2.1 and return to the configure mode.
PE4(config)#interface xe11	Enter the interface mode for xe11.
PE4(config-if)#speed 10g	Set the speed to 10g.
PE4(config-if)#static-channel-group 2	Attach the static-channel-group 2, the LAG interface sa2 to xe11.
PE4(config-if)#exit	Exit interface mode xe11 and return to the configure mode.
PE4(config)#commit	Commit the transaction.

CE2

The following configuration steps under CE2 are set up to enable VLANs and configure interfaces for carrying VLAN traffic.

CE2#configure terminal	Enter configure mode.
CE2(config)#bridge 1 protocol ieee vlan-bridge	Set up bridge 1 to use the IEEE VLAN bridge protocol.
CE2(config)#vlan 2-100 bridge 1 state enable	Configure VLANs from 2-100 and associate them with bridge 1.
CE2(config)#interface xe24	Enter interface mode xe24.
CE2(config-if)#switchport	Configure the interface xe24 as a Layer 2 switch port.
CE2(config-if)#bridge-group 1	Associate xe24 to bridge 1.
CE2(config-if)#switchport mode trunk	Configure xe24 as a trunk port.

CE2(config-if)#switchport trunk allowed vlan all	Allow all configured VLANs on the trunk interface xe24.
CE2(config-if)#exit	Exit interface mode xe24.
CE2(config)#interface po1	Enter interface mode and configure LAG interface port-channel 1 (po1).
CE2(config-if)#switchport	Configures port-channel 1 as a Layer 2 switch port.
CE2(config-if)#bridge-group 1	Associate po1 to bridge 1.
CE2(config-if)#switchport mode trunk	Configure po1 as a trunk port.
CE2(config-if)#switchport trunk allowed vlan all	Allow all configured VLANs on the trunk port-channel po1.
CE2(config-if)#exit	Exit interface mode po1.
CE2(config)#interface xe22	Enter interface mode xe22.
CE2(config-if)#lacp timeout short	Configure LACP timeout as short.
CE2(config-if)#channel-group 1 mode active	Add member to the LAG interface.
CE2(config-if)#exit	Exit interface mode xe22.
CE2(config-if)#interface xe23	Enter interface mode xe23 .
CE2(config-if)#lacp timeout short	Configure LACP timeout as short.
CE2(config-if)#channel-group 1 mode active	Add member to the LAG interface.
CE2(config-if)#commit	Commit the transaction.
CE2(config-if)#end	Exit interface mode xe23 and configure mode.

EVPN MPLS Active-Standby MH Validation

The following show outputs provide validation results for both single-active and port-active modes, covering ELINE and ELAN services configurations with LDP as the underlay MPLS path.

Single-Active

The following show output displays the types of load-balancing port selection criteria (PSC) used on configured static aggregators for CE1, PE1, PE2, PE3, PE4, and CE2 devices in the network [Figure 3-7](#) using the **show static-channel-group** command.

```
CE1#show static-channel-group
Static Aggregator: sa1
Member Status
xe48    up
-----
Static Aggregator: sa2
Member Status
xe50    up

PE1#show static-channel-group
Static Aggregator: sa1
Member Status weight
xe0     up

PE2#show static-channel-group
Static Aggregator: sa2
Member Status weight
xe8     up

PE3#show static-channel-group
Static Aggregator: sa1
Member Status weight
xe2     up
```

```
PE4#show static-channel-group
Static Aggregator: sa2
Member Status weight
xe11 up
```

```
CE2#show static-channel-group
Static Aggregator: sa1
Member Status weight
xe23 up
```

```
-----
Static Aggregator: sa2
Member Status weight
ge11 up
```

Single-Active ELINE

The following show output displays the active EVPN MPLS Tunnels and load balance for ELINE on PE1, PE2, PE3, and PE4 devices in the network [Figure 3-7](#) using the **show evpn load-balance all** and **show evpn mpls xconnect tunnel** commands.

```
PE1#show evpn load-balance all
ESI                               AC-IF/PE    PE-IP-ADDRESS  Redundancy    Service-carving  weight  Revertive  AC-DF
Status
=====
00:11:22:33:00:00:00:55:66:77  sa1.1      10.10.10.1     single-active  auto             0       NO         NO
ACTIVE
00:11:22:33:00:00:00:55:66:77  ----      10.10.10.2     single-active  auto             0       NO         NO
----
```

```
PE1#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination    Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
10.10.10.1  10.10.10.4    Installed   00:14:05     00:03:58    1800         1700
10.10.10.1  10.10.10.3    Installed   00:14:05     00:04:29    1800         1700
```

Total number of entries are 2

```
PE2#show evpn load-balance all
ESI                               AC-IF/PE    PE-IP-ADDRESS  Redundancy    Service-carving  weight  Revertive  AC-DF
Status
=====
00:11:22:33:00:00:00:55:66:77  ----      10.10.10.1     single-active  auto             0       NO         NO
----
00:11:22:33:00:00:00:55:66:77  sa2.1      10.10.10.2     single-active  auto             0       NO         NO
STANDBY
ELINE
```

```
PE2#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination    Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
10.10.10.2  10.10.10.4    Installed   00:12:33     00:04:08    1800         1700
10.10.10.2  10.10.10.3    Installed   00:12:33     00:04:08    1800         1700
```

Total number of entries are 2

```
PE3#show evpn load-balance all
ESI                               AC-IF/PE    PE-IP-ADDRESS  Redundancy    Service-carving  weight  Revertive  AC-DF
Status
=====
00:12:22:33:00:00:00:55:66:77  sa1.1      10.10.10.3     single-active  auto             0       NO         NO
ACTIVE
00:12:22:33:00:00:00:55:66:77  ----      10.10.10.4     single-active  auto             0       NO         NO
----
```

```
PE3#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination    Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
10.10.10.3  10.10.10.2    Installed   00:13:15     00:04:12    1700         1800
10.10.10.3  10.10.10.1    Installed   00:13:15     00:04:44    1700         1800
```

Total number of entries are 2

```
PE4#show evpn load-balance all
ESI                               AC-IF/PE    PE-IP-ADDRESS  Redundancy    Service-carving  weight  Revertive  AC-DF
Status
=====
00:12:22:33:00:00:00:55:66:77  ----      10.10.10.3     single-active  auto            0       NO         NO
-----
00:12:22:33:00:00:00:55:66:77  sa2.1      10.10.10.4     single-active  auto            0       NO         NO
STANDBY
```

```
PE4#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination    Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
10.10.10.4   10.10.10.2     Installed   00:12:52     00:04:17    1700        1800
10.10.10.4   10.10.10.1     Installed   00:12:52     00:04:17    1700        1800
```

Total number of entries are 2

Single-Active ELAN

The following show output displays the active EVPN SR Tunnels and load balance for ELAN on PE1, PE2, PE3, and PE4 devices in the network [Figure 3-7](#) using the **show evpn mpls tunnel** and **show evpn load-balance all** commands.

```
PE1#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination    Status      Up/Down      Update      evpn-id
=====
10.10.10.1   10.10.10.2     Installed   00:17:00     00:17:00    3000
10.10.10.1   10.10.10.4     Installed   00:18:10     00:18:10    3000
10.10.10.1   10.10.10.3     Installed   00:18:10     00:18:10    3000
```

Total number of entries are 3

```
PE1#show evpn load-balance all
ESI                               AC-IF/PE    PE-IP-ADDRESS  Redundancy    Service-carving  weight  Revertive  AC-DF
Status
=====
00:11:22:33:00:00:00:55:66:77  sa1.1      10.10.10.1     single-active  auto            0       NO         NO
ACTIVE
00:11:22:33:00:00:00:55:66:77  ----      10.10.10.2     single-active  auto            0       NO         NO
-----
```

```
PE2#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination    Status      Up/Down      Update      evpn-id
=====
10.10.10.2   10.10.10.4     Installed   00:17:09     00:17:09    3000
10.10.10.2   10.10.10.3     Installed   00:17:09     00:17:09    3000
10.10.10.2   10.10.10.1     Installed   00:17:09     00:17:09    3000
```

Total number of entries are 3

```
PE2#show evpn load-balance all
ESI                               AC-IF/PE    PE-IP-ADDRESS  Redundancy    Service-carving  weight  Revertive  AC-DF
Status
=====
00:11:22:33:00:00:00:55:66:77  ----      10.10.10.1     single-active  auto            0       NO         NO
-----
00:11:22:33:00:00:00:55:66:77  sa2.1      10.10.10.2     single-active  auto            0       NO         NO
STANDBY
```

```
PE3#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination    Status      Up/Down      Update      evpn-id
=====
10.10.10.3   10.10.10.2     Installed   00:17:11     00:17:11    3000
10.10.10.3   10.10.10.1     Installed   00:18:21     00:18:21    3000
```

```
10.10.10.3      10.10.10.4      Installed      00:29:15      00:28:54      3000
```

Total number of entries are 3

```
PE3#show evpn load-balance all
```

ESI Status	AC-IF/PE	PE-IP-ADDRESS	Redundancy	Service-carving	weight	Revertive	AC-DF
00:12:22:33:00:00:00:55:66:77 ACTIVE	sa1.1	10.10.10.3	single-active	auto	0	NO	NO
00:12:22:33:00:00:00:55:66:77 ----	----	10.10.10.4	single-active	auto	0	NO	NO

```
PE4#show evpn mpls tunnel
```

```
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	evpn-id
10.10.10.4	10.10.10.2	Installed	00:17:13	00:17:13	3000
10.10.10.4	10.10.10.1	Installed	00:18:23	00:18:23	3000
10.10.10.4	10.10.10.3	Installed	00:29:18	00:29:14	3000

Total number of entries are 3

```
PE4#show evpn load-balance all
```

ESI Status	AC-IF/PE	PE-IP-ADDRESS	Redundancy	Service-carving	weight	Revertive	AC-DF
00:12:22:33:00:00:00:55:66:77 ----	----	10.10.10.3	single-active	auto	0	NO	NO
00:12:22:33:00:00:00:55:66:77 STANDBY	sa2.1	10.10.10.4	single-active	auto	0	NO	NO

Port-Active

The following show output displays the Ether Channel summary for CE1, CE2, PE1, PE2, PE3, and PE4 devices in the network [Figure 3-7](#) using the **show etherchannel summary** command.

```
CE1#show etherchannel summary
```

```
Aggregator pol 100001
Aggregator Type: Layer2
Admin Key: 0001 - Oper Key 0001
Link: xe48 (5049) sync: 0
Link: xe50 (5051) sync: 1
```

```
CE2#show etherchannel summary
```

```
Aggregator pol 100001
Aggregator Type: Layer2
Admin Key: 0001 - Oper Key 0001
Link: ge11 (5011) sync: 1
Link: xe23 (5023) sync: 0
```

```
PE1#show etherchannel summary
```

```
Aggregator pol 100001
Aggregator Type: Layer3
Admin Key: 0001 - Oper Key 0001
Link: xe0 (10004) sync: 0
```

```
PE2#show etherchannel summary
```

```
Aggregator pol 100001
Aggregator Type: Layer3
Admin Key: 0001 - Oper Key 0001
Link: xe8 (10029) sync: 1
```

```
PE3#show etherchannel summary
```

```
Aggregator pol 100001
```

```

Aggregator Type: Layer3
Admin Key: 0001 - Oper Key 0001
  Link: xe2 (10003) sync: 0
PE4#show etherchannel summary
Aggregator pol 100001
Aggregator Type: Layer3
Admin Key: 0001 - Oper Key 0001
  Link: xe11 (10012) sync: 1

```

The following show output displays the status of LDP sessions on PE1, PE2, PE3, PE4, P1, and P2 devices in the network [Figure 3-7](#) using the **show ldp session** command.

```

PE1#show ldp session
Codes: m - MD5 password is not set/unset.
      g - GR configuration not set/unset.
      t - TCP MSS not set/unset.
      Session has to be cleared manually

```

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	10.10.10.2	xe2	Passive	OPERATIONAL	30	00:06:57
	10.10.10.3	xe14	Passive	OPERATIONAL	30	00:07:12
	10.10.10.4	xe14	Passive	OPERATIONAL	30	00:06:42
	10.10.10.5	xe14	Passive	OPERATIONAL	30	00:07:26
	10.10.10.6	xe2	Passive	OPERATIONAL	30	00:06:36

```

PE2#show ldp session
Codes: m - MD5 password is not set/unset.
      g - GR configuration not set/unset.
      t - TCP MSS not set/unset.
      Session has to be cleared manually

```

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	10.10.10.1	xe4	Active	OPERATIONAL	30	00:07:05
	10.10.10.3	xe4	Passive	OPERATIONAL	30	00:07:05
	10.10.10.4	xe4	Passive	OPERATIONAL	30	00:07:05
	10.10.10.5	xe5	Passive	OPERATIONAL	30	00:07:03
	10.10.10.6	xe4	Passive	OPERATIONAL	30	00:07:13

```

P1#show ldp session
Codes: m - MD5 password is not set/unset.
      g - GR configuration not set/unset.
      t - TCP MSS not set/unset.
      Session has to be cleared manually

```

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	10.10.10.1	xe1	Active	OPERATIONAL	30	00:07:41
	10.10.10.2	xe2	Active	OPERATIONAL	30	00:07:11
	10.10.10.3	xe4	Active	OPERATIONAL	30	00:07:13
	10.10.10.4	xe3	Active	OPERATIONAL	30	00:07:10

```

P2#show ldp session
Codes: m - MD5 password is not set/unset.

```

g - GR configuration not set/unset.
 t - TCP MSS not set/unset.
 Session has to be cleared manually

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	10.10.10.1	xe12	Active	OPERATIONAL	30	00:06:55
	10.10.10.2	xe13	Active	OPERATIONAL	30	00:07:24
	10.10.10.3	xe11	Active	OPERATIONAL	30	00:01:47
	10.10.10.4	xe14	Active	OPERATIONAL	30	00:06:56

PE3#show ldp session

Codes: m - MD5 password is not set/unset.
 g - GR configuration not set/unset.
 t - TCP MSS not set/unset.
 Session has to be cleared manually

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	10.10.10.1	xe5	Active	OPERATIONAL	30	00:07:35
	10.10.10.2	xe5	Active	OPERATIONAL	30	00:07:20
	10.10.10.4	xe5	Passive	OPERATIONAL	30	00:07:07
	10.10.10.5	xe1	Passive	OPERATIONAL	30	00:07:21
	10.10.10.6	xe5	Passive	OPERATIONAL	30	00:01:50

PE4#show ldp session

Codes: m - MD5 password is not set/unset.
 g - GR configuration not set/unset.
 t - TCP MSS not set/unset.
 Session has to be cleared manually

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	10.10.10.1	xe0	Active	OPERATIONAL	30	00:07:09
	10.10.10.2	xe2	Active	OPERATIONAL	30	00:07:24
	10.10.10.3	xe0	Active	OPERATIONAL	30	00:07:11
	10.10.10.5	xe2	Passive	OPERATIONAL	30	00:07:22
	10.10.10.6	xe0	Passive	OPERATIONAL	30	00:07:03

The below show output displays the details about BGP L2VPN EVPN multihoming ES routes and Ethernet advertisement per ES for PE1, PE2, PE3, and PE4 devices in the network [Figure 3-7](#) using the **show bgp l2vpn evpn multihoming es-route** command.

PE1#show bgp l2vpn evpn multihoming es-route

RD[10.10.10.1:64512] VRF[evpn-gvrf-1]:

ESI	PE IP-Address	Encap	Peer IP	Algo	AC-DF	DP	weight
00:00:00:11:11:77:77:00:00:00	10.10.10.1	MPLS	-----	DFT	no	no	0
00:00:00:11:11:77:77:00:00:00	10.10.10.2	MPLS	10.10.10.2	DFT	no	no	0

RD[10.10.10.2:64512]

ESI	PE IP-Address	Encap	Peer IP	Algo
00:00:00:11:11:77:77:00:00:00	10.10.10.2	MPLS	10.10.10.2	DFT

PE2#show bgp l2vpn evpn multihoming es-route

RD[10.10.10.1:64512]

ESI	PE IP-Address	Encap	Peer IP	Algo	AC-DF	DP	weight
-----	---------------	-------	---------	------	-------	----	--------

```

00:00:00:11:11:77:77:00:00:00 10.10.10.1 MPLS 10.10.10.1 DFT no no 0

RD[10.10.10.2:64512] VRF[evpn-gvrf-1]:
ESI PE IP-Address Encap Peer IP Algo AC-DF DP weight
00:00:00:11:11:77:77:00:00:00 10.10.10.1 MPLS 10.10.10.1 DFT no no 0
00:00:00:11:11:77:77:00:00:00 10.10.10.2 MPLS ----- DFT no no 0

```

PE3#show bgp l2vpn evpn multihoming es-route

```

RD[10.10.10.3:64512] VRF[evpn-gvrf-1]:
ESI PE IP-Address Encap Peer IP Algo
AC-DF DP weight
00:00:00:22:22:77:77:00:00:00 10.10.10.3 MPLS ----- DFT
no no 0
00:00:00:22:22:77:77:00:00:00 10.10.10.4 MPLS 10.10.10.4 DFT
no no 0

```

```

RD[10.10.10.4:64512]
ESI PE IP-Address Encap Peer IP Algo
AC-DF DP weight
00:00:00:22:22:77:77:00:00:00 10.10.10.4 MPLS 10.10.10.4 DFT
no no 0

```

PE4#show bgp l2vpn evpn multihoming es-route

```

RD[10.10.10.3:64512]
ESI PE IP-Address Encap Peer IP Algo AC-DF DP weight
00:00:00:22:22:77:77:00:00:00 10.10.10.3 MPLS 10.10.10.3 DFT no no 0

```

```

RD[10.10.10.4:64512] VRF[evpn-gvrf-1]:
ESI PE IP-Address Encap Peer IP Algo AC-DF DP weight
00:00:00:22:22:77:77:00:00:00 10.10.10.3 MPLS 10.10.10.3 DFT no no 0
00:00:00:22:22:77:77:00:00:00 10.10.10.4 MPLS ----- DFT no no 0

```

The following show output displays the details about Layer 2 Virtual Private Network (L2VPN) Ethernet Virtual Private Network (EVPN) routes on PE1, PE2, PE3, and PE4 devices in the network [Figure 3-7](#) using the **show bgp l2vpn evpn multihoming ethernet-ad-per-es** and **show bgp l2vpn evpn multihoming ethernet-ad-per-evi** commands.

PE1#show bgp l2vpn evpn multihoming ethernet-ad-per-es

```

RD[10.10.10.1:1700] VRF[vrf2]:
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.2 MPLS P flag
00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.3 MPLS B flag
00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.4 MPLS P flag

```

```

RD[10.10.10.1:64512] VRF[evpn-gvrf-1]:
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.1 MPLS B flag

```

```

RD[10.10.10.2:64512]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.2 MPLS P flag

```

```

RD[10.10.10.3:64512]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.3 MPLS B flag

```

```

RD[10.10.10.4:64512]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.4 MPLS P flag

```

PE1#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

```

RD[10.10.10.1:1700] VRF[vrf2]:
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:11:11:77:77:00:00:00 1800 27522 10.10.10.1 MPLS B flag
00:00:00:11:11:77:77:00:00:00 1800 27520 10.10.10.2 MPLS P flag
00:00:00:22:22:77:77:00:00:00 1700 27520 10.10.10.3 MPLS B flag
00:00:00:22:22:77:77:00:00:00 1700 27520 10.10.10.4 MPLS P flag

```

```

RD[10.10.10.2:1700]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags

```

```

00:00:00:11:11:77:77:00:00:00 1800 27520 10.10.10.2 MPLS P flag

RD[10.10.10.3:1700]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:22:22:77:77:00:00:00 1700 27520 10.10.10.3 MPLS B flag

RD[10.10.10.4:1700]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:22:22:77:77:00:00:00 1700 27520 10.10.10.4 MPLS P flag

PE2#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[10.10.10.1:64512]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.1 MPLS B flag

RD[10.10.10.2:1700] VRF[vrf2]:
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.1 MPLS B flag
00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.3 MPLS B flag
00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.4 MPLS P flag

RD[10.10.10.2:64512] VRF[evpn-gvrf-1]:
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.2 MPLS P flag

RD[10.10.10.3:64512]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.3 MPLS B flag

RD[10.10.10.4:64512]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.4 MPLS P flag

PE2#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[10.10.10.1:1700]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:11:11:77:77:00:00:00 1800 27522 10.10.10.1 MPLS B flag

RD[10.10.10.2:1700] VRF[vrf2]:
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:11:11:77:77:00:00:00 1800 27522 10.10.10.1 MPLS B flag
00:00:00:11:11:77:77:00:00:00 1800 27520 10.10.10.2 MPLS P flag
00:00:00:22:22:77:77:00:00:00 1700 27520 10.10.10.3 MPLS B flag
00:00:00:22:22:77:77:00:00:00 1700 27520 10.10.10.4 MPLS P flag

RD[10.10.10.3:1700]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:22:22:77:77:00:00:00 1700 27520 10.10.10.3 MPLS B flag

RD[10.10.10.4:1700]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:22:22:77:77:00:00:00 1700 27520 10.10.10.4 MPLS P flag

PE3#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[10.10.10.1:64512]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.1 MPLS B flag

RD[10.10.10.2:64512]
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.2 MPLS P flag

RD[10.10.10.3:1700] VRF[vrf2]:
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.2 MPLS P flag
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.1 MPLS B flag
00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.4 MPLS P flag

RD[10.10.10.3:64512] VRF[evpn-gvrf-1]:
ESI Eth-Tag VNID/LABEL Nexthop IP Encap Flags

```



```

00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.3 MPLS B flag

RD[10.10.10.4:64512]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.4 MPLS P flag

PE3#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[10.10.10.1:1700]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:11:11:77:77:00:00:00 1800      27522      10.10.10.1 MPLS B flag

RD[10.10.10.2:1700]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:11:11:77:77:00:00:00 1800      27520      10.10.10.2 MPLS P flag

RD[10.10.10.3:1700] VRF[vrf2]:
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:11:11:77:77:00:00:00 1800      27520      10.10.10.2 MPLS P flag
00:00:00:11:11:77:77:00:00:00 1800      27522      10.10.10.1 MPLS B flag
00:00:00:22:22:77:77:00:00:00 1700      27520      10.10.10.3 MPLS B flag
00:00:00:22:22:77:77:00:00:00 1700      27520      10.10.10.4 MPLS P flag

RD[10.10.10.4:1700]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:22:22:77:77:00:00:00 1700      27520      10.10.10.4 MPLS P flag

PE4#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[10.10.10.1:64512]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.1 MPLS B flag

RD[10.10.10.2:64512]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.2 MPLS P flag

RD[10.10.10.3:64512]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.3 MPLS B flag

RD[10.10.10.4:1700] VRF[vrf2]:
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.1 MPLS B flag
00:00:00:11:11:77:77:00:00:00 4294967295 440336 10.10.10.2 MPLS P flag
00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.3 MPLS B flag

RD[10.10.10.4:64512] VRF[evpn-gvrf-1]:
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:22:22:77:77:00:00:00 4294967295 440336 10.10.10.4 MPLS P flag

PE4#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[10.10.10.1:1700]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:11:11:77:77:00:00:00 1800      27522      10.10.10.1 MPLS B flag

RD[10.10.10.2:1700]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:11:11:77:77:00:00:00 1800      27520      10.10.10.2 MPLS P flag

RD[10.10.10.3:1700]
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:22:22:77:77:00:00:00 1700      27520      10.10.10.3 MPLS B flag

RD[10.10.10.4:1700] VRF[vrf2]:
ESI                               Eth-Tag  VNID/LABEL  Nexthop IP  Encap  Flags
00:00:00:11:11:77:77:00:00:00 1800      27522      10.10.10.1 MPLS B flag
00:00:00:11:11:77:77:00:00:00 1800      27520      10.10.10.2 MPLS P flag
00:00:00:22:22:77:77:00:00:00 1700      27520      10.10.10.3 MPLS B flag
00:00:00:22:22:77:77:00:00:00 1700      27520      10.10.10.4 MPLS P flag

```

Port-Active ELINE

The following show output displays the active EVPN MPLS Tunnels for ELINE on PE1, PE2, PE3, and PE4 devices in the network [Figure 3-7](#) using the **show evpn mpls xconnect tunnel** command.

```
PE1#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
10.10.10.1  10.10.10.3      AC-Down     00:31:41     00:31:41     4           1700
10.10.10.1  10.10.10.4      AC-Down     00:31:41     00:31:41     4           1700
Total number of entries are 2
```

```
PE2#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
10.10.10.2  10.10.10.3      Installed   00:12:21     00:11:40     1800        1700
10.10.10.2  10.10.10.4      Installed   00:17:43     00:17:37     1800        1700
Total number of entries are 2
```

```
PE3#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
10.10.10.3  10.10.10.1      AC-Down     00:12:26     00:12:26     1700        1800
10.10.10.3  10.10.10.2      AC-Down     00:12:26     00:12:26     1700        1800
Total number of entries are 2
```

```
PE4#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
10.10.10.4  10.10.10.1      Installed   00:12:28     00:12:28     1700        1800
10.10.10.4  10.10.10.2      Installed   00:12:28     00:12:28     1700        1800
Total number of entries are 2
```

Port-Active ELAN

The following show outputs provide validation for ELAN configurations.

The following show output displays the active EVPN MPLS Tunnels for ELAN on PE1, PE2, PE3, and PE4 devices in the network [Figure 3-7](#) using the **show evpn mpls tunnel** command.

```
PE1#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      evpn-id
=====
10.10.10.1  10.10.10.4      Installed   00:02:35     00:02:35     3000
10.10.10.1  10.10.10.3      Installed   00:03:00     00:03:00     3000
10.10.10.1  10.10.10.2      Installed   00:03:26     00:03:26     3000
Total number of entries are 3
```

```
PE2#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      evpn-id
=====
10.10.10.2  10.10.10.4      Installed   00:02:45     00:02:45     3000
10.10.10.2  10.10.10.3      Installed   00:03:10     00:03:10     3000
10.10.10.2  10.10.10.1      Installed   00:03:36     00:03:36     3000
Total number of entries are 3
```

```
PE3#show evpn mpls tunnel
```

```
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	evpn-id
10.10.10.3	10.10.10.4	Installed	00:02:56	00:02:56	3000
10.10.10.3	10.10.10.2	Installed	00:03:22	00:03:22	3000
10.10.10.3	10.10.10.1	Installed	00:03:22	00:03:22	3000

```
Total number of entries are 3
```

```
PE4#show evpn mpls tunnel
```

```
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	evpn-id
10.10.10.4	10.10.10.3	Installed	00:03:00	00:03:00	3000
10.10.10.4	10.10.10.1	Installed	00:03:00	00:03:00	3000
10.10.10.4	10.10.10.2	Installed	00:03:00	00:03:00	3000

```
Total number of entries are 3
```

The following show output displays the EVPN active multi-homed and load-balanced details on PE1, PE2, PE3, and PE4 devices in the network [Figure 3-7](#) using the **show evpn load-balance port-active** and **show evpn multi-homing all** commands.

```
PE1#show evpn load-balance port-active
```

ESI	AC-IF/PE	PE-IP-ADDRESS	Redundancy	Service-carving	weight	Revertive	AC-DF
00:00:00:11:11:77:77:00:00:00	LOCAL	10.10.10.1	port-active	auto	0	NO	NA
STANDBY							
00:00:00:11:11:77:77:00:00:00	REMOTE	10.10.10.2	port-active	auto	0	NO	NA
ACTIVE							
00:00:00:22:22:77:77:00:00:00	REMOTE	10.10.10.3	port-active	----	----	----	----
STANDBY							
00:00:00:22:22:77:77:00:00:00	REMOTE	10.10.10.4	port-active	----	----	----	----
ACTIVE							

```
PE1#show evpn multi-homing all
```

ESI	Access-IF	PE-IP-ADDRESS
00:00:00:11:11:77:77:00:00:00	po1	10.10.10.1
00:00:00:11:11:77:77:00:00:00	----	10.10.10.2
00:00:00:22:22:77:77:00:00:00	----	10.10.10.3
00:00:00:22:22:77:77:00:00:00	----	10.10.10.4

Total number of entries are 4

```
PE2#show evpn load-balance port-active
```

ESI	AC-IF/PE	PE-IP-ADDRESS	Redundancy	Service-carving	weight	Revertive	AC-DF	Status
00:00:00:11:11:77:77:00:00:00	REMOTE	10.10.10.1	port-active	auto	0	NO	NA	STANDBY
00:00:00:11:11:77:77:00:00:00	LOCAL	10.10.10.2	port-active	auto	0	NO	NA	ACTIVE
00:00:00:22:22:77:77:00:00:00	REMOTE	10.10.10.3	port-active	---	----	----	----	STANDBY
00:00:00:22:22:77:77:00:00:00	REMOTE	10.10.10.4	port-active	----	----	----	----	ACTIVE

```
PE2#show evpn multi-homing all
```

ESI	Access-IF	PE-IP-ADDRESS
00:00:00:11:11:77:77:00:00:00	----	10.10.10.1
00:00:00:11:11:77:77:00:00:00	po1	10.10.10.2
00:00:00:22:22:77:77:00:00:00	----	10.10.10.3
00:00:00:22:22:77:77:00:00:00	----	10.10.10.4

Total number of entries are 4

```
PE3#show evpn load-balance port-active
```

ESI	AC-IF/PE	PE-IP-ADDRESS	Redundancy	Service-carving	weight	Revertive	AC-DF
00:00:00:11:11:77:77:00:00:00	LOCAL	10.10.10.1	port-active	auto	0	NO	NA
STANDBY							
00:00:00:11:11:77:77:00:00:00	REMOTE	10.10.10.2	port-active	auto	0	NO	NA
ACTIVE							
00:00:00:22:22:77:77:00:00:00	REMOTE	10.10.10.3	port-active	----	----	----	----
STANDBY							
00:00:00:22:22:77:77:00:00:00	REMOTE	10.10.10.4	port-active	----	----	----	----
ACTIVE							

```

00:00:00:11:11:77:77:00:00:00 REMOTE 10.10.10.1 port-active ---- ---- ----
STANDBY
00:00:00:11:11:77:77:00:00:00 REMOTE 10.10.10.2 port-active ---- ---- ----
ACTIVE
00:00:00:22:22:77:77:00:00:00 LOCAL 10.10.10.3 port-active auto 0 NO NA
STANDBY
00:00:00:22:22:77:77:00:00:00 REMOTE 10.10.10.4 port-active auto 0 NO NA
ACTIVE

```

```
PE3#show evpn multi-homing all
```

```

ESI          Access-IF  PE-IP-ADDRESS
=====
00:00:00:11:11:77:77:00:00:00 ---- 10.10.10.1
00:00:00:11:11:77:77:00:00:00 ---- 10.10.10.2
00:00:00:22:22:77:77:00:00:00 po1 10.10.10.3
00:00:00:22:22:77:77:00:00:00 ---- 10.10.10.4
Total number of entries are 4

```

```
PE4#show evpn load-balance port-active
```

```

ESI          AC-IF/PE  PE-IP-ADDRESS  Redundancy  Service-carving  weight  Revertive  AC-DF
Status
=====
00:00:00:11:11:77:77:00:00:00 REMOTE 10.10.10.1 port-active ---- ---- ----
STANDBY
00:00:00:11:11:77:77:00:00:00 REMOTE 10.10.10.2 port-active ---- ---- ----
ACTIVE
00:00:00:22:22:77:77:00:00:00 REMOTE 10.10.10.3 port-active auto 0 NO NA
STANDBY
00:00:00:22:22:77:77:00:00:00 LOCAL 10.10.10.4 port-active auto 0 NO NA
ACTIVE

```

```
PE4#show evpn multi-homing all
```

```

ESI          Access-IF  PE-IP-ADDRESS
=====
00:00:00:11:11:77:77:00:00:00 ---- 10.10.10.1
00:00:00:11:11:77:77:00:00:00 ---- 10.10.10.2
00:00:00:22:22:77:77:00:00:00 ---- 10.10.10.3
00:00:00:22:22:77:77:00:00:00 po1 10.10.10.4

```

EVPN SR Active-Standby Multi-Homing Configuration

This section illustrates the Multi-Homed setup for the EVPN Segment Routing (SR) Active-Standby configuration, showcasing examples for both ELINE and ELAN services with SR as the underlay MPLS path.

EVPN SR Active-Standby MH Topology

Figure 3-8 consists of customer edge routers CE1 and CE2, along with IPv4 Provider Edge routers PE1, PE2, PE3, and PE4, all interconnected through the core routers P1 and P2 in the IPv4 MPLS provider network.



Figure 3-8: EVPN MPLS AS MH Configuration

CE1

The following configuration steps under CE1 are set up to enable VLANs and configure interfaces for carrying VLAN traffic.

CE1#configure terminal	Enter configure mode.
CE1(config)#bridge 1 protocol ieee vlan-bridge	Set up bridge 1 to use the IEEE VLAN bridge protocol.
CE1(config)#vlan 2-100 bridge 1 state enable	Configure VLANs from 2-100 and associate them with bridge 1.
CE1(config)#interface xe54	Enter interface mode xe54.
CE1(config-if)#switchport	Configure the interface xe54 as a Layer 2 switch port.
CE1(config-if)#bridge-group 1	Associate xe54 to bridge 1.
CE1(config-if)#switchport mode trunk	Configure xe54 as a trunk port.
CE1(config-if)#switchport trunk allowed vlan all	Allow all configured VLANs on the trunk interface xe54.
CE1(config-if)#exit	Exit interface mode xe54.
CE1(config)#interface po1	Enter interface mode and configure LAG interface port-channel 1 (po1).
CE1(config-if)#switchport	Configures port-channel 1 as a Layer 2 switch port.
CE1(config-if)#bridge-group 1	Associate po1 to bridge 1.
CE1(config-if)#switchport mode trunk	Configure po1 as a trunk port.
CE1(config-if)#switchport trunk allowed vlan all	Allow all configured VLANs on the trunk port-channel po1.
CE1(config-if)#exit	Exit interface mode po1.
CE1(config)#interface xe48	Enter interface mode xe48.
CE1(config-if)#lacp timeout short	Configure LACP timeout as short.
CE1(config-if)#channel-group 1 mode active	Add member to the LAG interface.
CE1(config-if)#exit	Exit interface mode xe48.
CE1(config-if)#interface xe50	Enter interface mode xe50.

CE1(config-if)#lacp timeout short	Configure LACP timeout as short.
CE1(config-if)#channel-group 1 mode active	Add member to the LAG interface.
CE1(config-if)#commit	Commit the transaction.
CE1(config-if)#end	Exit interface mode xe50 and configure mode.

PE1: Loopback Interface

The configuration on PE1 for a loopback interface with IP address 10.10.10.1/32 secondary is set up to provide IP connectivity for the ISIS router.

PE1#configure terminal	Enter configure mode.
PE1(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE1(config-if)#ip address 10.10.10.1/32 secondary	Configure a secondary IP address, 10.10.10.1/32, on the loopback interface.
PE1(config-if)#ip router isis 1	Enable ISIS routing on a loopback interface lo for area 1.
PE1(config-if)#prefix-sid index 800	Configure a prefix segment identifier (prefix-SID) index value as 800.
PE1(config-if)#exit	Exit interface mode lo.
PE1(config)#commit	Commit the transaction.

PE1: Configure SR

The following configurations aim to activate Segment Routing (SR) on PE1 and make MPLS the preferred method for segment routing, optimizing routing efficiency.

PE1(config)#segment-routing	Configure segment routing on PE1 device.
PE1(config-sr)#mpls sr-prefer	Set MPLS as the preferred segment routing protocol over others.
PE1(config-sr)#exit	Exit the router SR mode.
PE1(config)#commit	Commit the transaction.

PE1: Global LDP

The configuration on PE1 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE1(config)#router ldp	Enter the Router LDP mode.
PE1(config-router)#router-id 10.10.10.1	Set the router ID for LDP to 10.10.10.1.
PE1(config-router)#transport-address ipv4 10.10.10.1	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
PE1(config-router)#targeted-peer ipv4 10.10.10.2	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.

PE1(config-router)#targeted-peer ipv4 10.10.10.3	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE1(config-router)#targeted-peer ipv4 10.10.10.4	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE1(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: Global EVPN MPLS Command

The configuration on PE1 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE1(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE1, enabling it to participate in EVPN MPLS services.
PE1(config)#commit	Commit candidate configuration to be running configuration.
PE1(config)#evpn mpls vtep-ip-global 10.10.10.1	Configure the global VTEP IP address 10.10.10.1, associating it with the loopback IP.
PE1(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE1(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE1 to support multi-homed EVPN MPLS services.
PE1(config)#commit	Commit the transaction.

PE1: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE1 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE1(config)#interface xe1	Enter interface mode xe1.
PE1(config-if)#ip address 10.1.1.1/30	Configure an IP address, 10.1.1.1/30, on the interface xe1.
PE1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE1(config-if)#ip router isis 1	Enable ISIS IPv4 routing on an interface xe1.
PE1(config-if)#exit	Exit interface mode xe1.
PE1(config)#commit	Commit the transaction.
PE1(config)#interface xe2	Enter interface mode xe2.
PE1(config-if)#ip address 10.1.2.1/30	Configure an IP address, 10.1.2.1/30, on the interface xe2.

PE1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE1(config-if)#ip router isis 1	Enable ISIS IPv4 routing on an interface xe2.
PE1(config-if)#exit	Exit interface mode xe2.
PE1(config)#commit	Commit the transaction.

PE1: ISIS Configuration

The below configuration is performed to set up ISIS on PE1, to enable MPLS Traffic Engineering, Segment Routing, and other related features for efficient routing and network management.

PE1(config)#router isis 1	Enter router ISIS mode.
PE1(config-router)#is-type level-1-2	Configure IS-Type as Level-1-2 specifies that the router will participate in both Level-1 and Level-2 areas within the ISIS network.
PE1(config-router)#metric-style wide	Configure the new style of metric type as wide.
PE1(config-router)#mpls traffic-eng router-id 10.10.10.1	Configure the router's MPLS Traffic Engineering (TE) router ID TLV to 10.10.10.1, which is used for MPLS-TE path calculations.
PE1(config-router)#mpls traffic-eng level-1	Enable MPLS-TE for IS-Type Level-1 routing.
PE1(config-router)#mpls traffic-eng level-2	Enable MPLS-TE for IS-Type Level-2 routing.
PE1(config-router)#capability cspf	Enable Constraint Shortest Path First (CSPF) computation for traffic engineering.
PE1(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
PE1(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE1(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE1(config-router)#bfd all-interfaces	Configure BFD on all interfaces for fast link failure detection.
PE1(config-router)#net 49.0000.0000.0001.00	Set a Network Entity Title (NET) for this ISIS instance, specifying the area address and the system ID.
PE1(config-router)#isis segment-routing global block 17000 23500	Enable ISIS SR globally and allocates label blocks for Segment Routing.
PE1(config-router)#segment-routing mpls	Enable SR ISIS.
PE1(config-router)#exit	Exit router ISIS mode and return to configure mode.
PE1(config)#commit	Commit the transaction.

PE1: BGP Configuration

The below BGP configuration on PE1 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

PE1(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
PE1(config-router)#bgp router-id 10.10.10.1	Configure BGP router ID 10.10.10.1, identifying PE1 within the BGP network.
PE1(config-router)#neighbor 10.10.10.2 remote-as 65010	Configure neighbor 10.10.10.2 as an iBGP neighbor with their remote AS number 65010.
PE1(config-router)#neighbor 10.10.10.2 update-source lo	Configure neighbor 10.10.10.2 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE1(config-router)#neighbor 10.10.10.3 remote-as 65010	Configure neighbor 10.10.10.3 as an iBGP neighbor with their remote AS number 65010.
PE1(config-router)#neighbor 10.10.10.3 update-source lo	Configure neighbor 10.10.10.3 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE1(config-router)#neighbor 10.10.10.4 remote-as 65010	Configure neighbor 10.10.10.4 as an iBGP neighbor with their remote AS number 65010.
PE1(config-router)#neighbor 10.10.10.4 update-source lo	Configure neighbor 10.10.10.4 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE1(config-router)#neighbor 10.10.10.2 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE1(config-router)#neighbor 10.10.10.3 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE1(config-router)#neighbor 10.10.10.4 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE1(config-router)#neighbor 10.10.10.2 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE1(config-router)#neighbor 10.10.10.3 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE1(config-router)#neighbor 10.10.10.4 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE1(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE1(config-router-af)#neighbor 10.10.10.2 activate	Activate EVPN for iBGP neighbor 10.10.10.2 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE1(config-router-af)#neighbor 10.10.10.3 activate	Activate EVPN for iBGP neighbor 10.10.10.3 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE1(config-router-af)#neighbor 10.10.10.4 activate	Activate EVPN for iBGP neighbor 10.10.10.4 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE1(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE1(config-router)#commit	Commit the transaction.
PE1(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE1: MAC VRF Configuration

The below MAC VRF configuration on PE1 is carried out to define and set up VRFs named `vrf2` and `vp1s1001` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE1(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE1(config-vrf)#rd 10.10.10.1:1700	Configure Route-Distinguisher value of 10.10.10.1:1700.
PE1(config-vrf)#route-target both 1700:1700	Configure import and export values for the vrf2 as 1700:1700.
PE1(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE1(config)#mac vrf vpls1001	Enter VRF mode named vpls1001.
PE1(config-vrf)#rd 10.10.10.1:1001	Configure Route-Distinguisher value of 10.10.10.1:1001.
PE1(config-vrf)#route-target both 1001:1001	Configure import and export values for the vpls1001 as 1001:1001.
PE1(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE1 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

PE1(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with a source identifier of 1800 and a target identifier of 1700.
PE1(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE1(config-evpn-mpls)#commit	Commit the transaction.
PE1(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
PE1(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier an identifier of 3000.
PE1(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Map VRF vpls1001 to the EVPN-VPWS identifier
PE1(config-evpn-mpls)#commit	Commit the transaction.
PE1(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE1 is carried out to configure various parameters including system-mac, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

PE1(config)#interface po1	Enter the port channel interface mode for po1
PE1(config-if)#load-interval 30	Set the load interval to 30.
PE1(config-if)#evpn multi-homed system-mac 0000.1111.7777 load-balancing port-active	Configure the system-mac address 0000.1111.7777 for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE1(config-if-es)#service-carving auto	Configure service carving as auto.
PE1(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE1(config-if)#exit	Exit interface mode po1 and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1(config)#interface po1.1 switchport	Create a Layer 2 sub-interface po1.1 within the port channel.
PE1(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE1(config-if)#load-interval 30	Set the load interval to 30.
PE1(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE1(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE1(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE1(config-if)#exit	Exit interface mode po1.1 and return to the configure mode.
PE1(config)#interface xe0	Enter the interface mode for xe0.
PE1(config-if)#speed 10g	Set the speed to 10g.
PE1(config-if)#channel-group 1 mode active	Attach LAG interface po1.
PE1(config-if)#exit	Exit interface mode xe0 and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE1 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

PE1(config)#interface sa1	Enter the single active interface mode for sa1
PE1(config-if)#load-interval 30	Set the load interval to 30.
PE1(config-if)#evpn multi-homed esi 00:00:11:11:77:77 load-balancing single-active	Configure the ESI with the value with the value 00:00:11:11:77:77 for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE1(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE1(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE1(config-if)#exit	Exit interface mode sa1 and return to the configure mode.
PE1(config)#commit	Commit the transaction.
PE1(config)#interface sa1.1 switchport	Create a Layer 2 sub-interface sa1.1 within the port channel.
PE1(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE1(config-if)#load-interval 30	Set the load interval to 30.
PE1(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE1(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE1(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE1(config-if)#exit	Exit interface mode sa1.1 and return to the configure mode.
PE1(config)#interface xe0	Enter the interface mode for xe0.
PE1(config-if)#speed 10g	Set the speed to 10g.
PE1(config-if)#static-channel-group 1	Attach the static-channel-group 1, the LAG interface sa1 to xe0.

PE1 (config-if) #exit	Exit interface mode <code>xe0</code> and return to the configure mode.
PE1 (config) #commit	Commit the transaction.

PE2: Loopback Interface

The configuration on PE2 for a loopback interface with IP address `10.10.10.2/32` secondary is set up to provide IP connectivity for the ISIS router.

PE2#configure terminal	Enter configure mode.
PE2 (config) #interface lo	Enter the interface mode for the loopback interface <code>lo</code> .
PE2 (config-if) #ip address 10.10.10.2/32 secondary	Configure a secondary IP address, <code>10.10.10.2/32</code> , on the loopback interface.
PE2 (config-if) #ip router isis 1	Enable ISIS routing on a loopback interface <code>lo</code> for area 1.
PE2 (config-if) #prefix-sid index 800	Configure a prefix segment identifier (prefix-SID) index value as 800.
PE2 (config-if) #exit	Exit interface mode <code>lo</code> .
PE2 (config) #commit	Commit the transaction.

PE2: Configure SR

The following configurations aim to activate Segment Routing (SR) on PE2 and make MPLS the preferred method for segment routing, optimizing routing efficiency.

PE2 (config) #segment-routing	Configure segment routing on PE2 device.
PE2 (config-sr) #mpls sr-prefer	Set MPLS as the preferred segment routing protocol over others.
PE2 (config-sr) #exit	Exit the router SR mode.
PE2 (config) #commit	Commit the transaction.

PE2: Global LDP

The configuration on PE2 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE2 (config) #router ldp	Enter the Router LDP mode.
PE2 (config-router) #router-id 10.10.10.2	Set the router ID for LDP to <code>10.10.10.2</code> .
PE2 (config-router) #transport-address ipv4 10.10.10.2	Configure the transport address for IPv4 (for IPv6 use <code>ipv6</code> parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
PE2 (config-router) #targeted-peer ipv4 10.10.10.1	Configure targeted peer for LDP using IPv4 addresses.
PE2 (config-router-targeted-peer) #exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE2 (config-router) #targeted-peer ipv4 10.10.10.3	Configure targeted peer for LDP using IPv4 addresses.
PE2 (config-router-targeted-peer) #exit-targeted-peer-mode	Exit router targeted-peer-mode.

PE2(config-router)#targeted-peer ipv4 10.10.10.4	Configure targeted peer for LDP using IPv4 addresses.
PE2(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE2(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE2: Global EVPN MPLS Command

The configuration on PE2 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE2(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE2, enabling it to participate in EVPN MPLS services.
PE2(config)#commit	Commit candidate configuration to be running configuration.
PE2(config)#evpn mpls vtep-ip-global 10.10.10.2	Configure the global VTEP IP address 10.10.10.2, associating it with the loopback IP.
PE2(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE2(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE2 to support multi-homed EVPN MPLS services.
PE2(config)#commit	Commit the transaction.

PE2: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE2 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE2(config)#interface xe4	Enter interface mode xe4.
PE2(config-if)#ip address 10.1.3.1/30	Configure an IP address, 10.1.3.1/30, on the interface xe4.
PE2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE2(config-if)#ip router isis 1	Enable ISIS routing on an interface xe4 for area 1.
PE2(config-if)#exit	Exit interface mode xe4.
PE2(config)#commit	Commit the transaction.
PE2(config)#interface xe5	Enter interface mode xe5.
PE2(config-if)#ip address 10.1.4.1/30	Configure an IP address, 10.1.4.1/30, on the interface xe5.
PE2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.

PE2(config-if)#ip router isis 1	Enable ISIS routing on an interface xe5 for area 1.
PE2(config-if)#exit	Exit interface mode xe5.
PE2(config)#commit	Commit the transaction.

PE2: ISIS Configuration

The below configuration is performed to set up ISIS on PE2, to enable MPLS Traffic Engineering, Segment Routing, and other related features for efficient routing and network management.

PE2(config)#router isis 1	Enter router ISIS mode.
PE2(config-router)#is-type level-1-2	Configure IS-Type as Level-1-2 specifies that the router will participate in both Level-1 and Level-2 areas within the ISIS network.
PE2(config-router)#metric-style wide	Configure the new style of metric type as wide.
PE2(config-router)#mpls traffic-eng router-id 10.10.10.2	Configure the router's MPLS Traffic Engineering (TE) router ID TLV to 10.10.10.2, which is used for MPLS-TE path calculations.
PE2(config-router)#mpls traffic-eng level-1	Enable MPLS-TE for IS-Type Level-1 routing.
PE2(config-router)#mpls traffic-eng level-2	Enable MPLS-TE for IS-Type Level-2 routing.
PE2(config-router)#capability cspf	Enable Constraint Shortest Path First (CSPF) computation for traffic engineering.
PE2(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
PE2(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE2(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE2(config-router)#bfd all-interfaces	Configure BFD on all interfaces for fast link failure detection.
PE2(config-router)#net 49.0000.0000.0002.00	Set a Network Entity Title (NET) for this ISIS instance, specifying the area address and the system ID.
PE2(config-router)#isis segment-routing global block 17000 23500	Enable ISIS SR globally and allocates label blocks for Segment Routing.
PE2(config-router)#segment-routing mpls	Enable SR ISIS.
PE2(config-router)#exit	Exit router ISIS mode and return to configure mode.
PE2(config)#commit	Commit the transaction.

PE2: BGP Configuration

The below BGP configuration on PE2 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

PE2(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
PE2(config-router)#bgp router-id 10.10.10.2	Configure BGP router ID 10.10.10.2, identifying PE2 within the BGP network.
PE2(config-router)#neighbor 10.10.10.1 remote-as 65010	Configure neighbor 10.10.10.1 as an iBGP neighbor with their remote AS number 65010.

PE2(config-router)#neighbor 10.10.10.1 update-source lo	Configure neighbor 10.10.10.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE2(config-router)#neighbor 10.10.10.3 remote-as 65010	Configure neighbor 10.10.10.3 as an iBGP neighbor with their remote AS number 65010.
PE2(config-router)#neighbor 10.10.10.3 update-source lo	Configure neighbor 10.10.10.3 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE2(config-router)#neighbor 10.10.10.4 remote-as 65010	Configure neighbor 10.10.10.4 as an iBGP neighbor with their remote AS number 65010.
PE2(config-router)#neighbor 10.10.10.4 update-source lo	Configure neighbor 10.10.10.4 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE2(config-router)#neighbor 10.10.10.1 fall- over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE2(config-router)#neighbor 10.10.10.3 fall- over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE2(config-router)#neighbor 10.10.10.4 fall- over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE2(config-router)#neighbor 10.10.10.1 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE2(config-router)#neighbor 10.10.10.3 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE2(config-router)#neighbor 10.10.10.4 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE2(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE2(config-router-af)#neighbor 10.10.10.1 activate	Activate EVPN for iBGP neighbor 10.10.10.1 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE2(config-router-af)#neighbor 10.10.10.3 activate	Activate EVPN for iBGP neighbor 10.10.10.3 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE2(config-router-af)#neighbor 10.10.10.4 activate	Activate EVPN for iBGP neighbor 10.10.10.4 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE2(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE2(config-router)#commit	Commit the transaction.
PE2(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE2: MAC VRF Configuration

The below MAC VRF configuration on PE2 is carried out to define and set up VRFs named `vrf2` and `vp1s1001` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE2(config)#mac vrf vrf2	Enter VRF mode named <code>vrf2</code> .
PE2(config-vrf)#rd 10.10.10.2:1700	Configure Route-Distinguisher value of 10.10.10.2:1700.

PE2(config-vrf)#route-target both 1700:1700	Configure import and export values for the vrf2 as 1700:1700.
PE2(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE2(config)#mac vrf vpls1001	Enter VRF mode named vpls1001.
PE2(config-vrf)#rd 10.10.10.2:1001	Configure Route-Distinguisher value of 10.10.10.2:1001.
PE2(config-vrf)#route-target both 1001:1001	Configure import and export values for the vpls1001 as 1001:1001.
PE2(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE2: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE2 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

PE2(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with a source identifier of 1800 and a target identifier of 1700.
PE2(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE2(config-evpn-mpls)#commit	Commit the transaction.
PE2(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
PE2(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier an identifier of 3000.
PE2(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Map VRF vpls1001 to the EVPN-VPWS identifier
PE2(config-evpn-mpls)#commit	Commit the transaction.
PE2(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE2 is carried out to configure various parameters including system-mac, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

PE2(config)#interface po1	Enter the port channel interface mode for po1
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#evpn multi-homed system-mac 0000.1111.7777 load-balancing port-active	Configure the system-mac address 0000.1111.7777 for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE2(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE2(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE2(config-if)#exit	Exit interface mode po1 and return to the configure mode.
PE2(config)#commit	Commit the transaction.
PE2(config)#interface po1.1 switchport	Create a Layer 2 sub-interface po1.1 within the port channel.
PE2(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.

PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE2(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE2(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE2(config-if)#exit	Exit interface mode <code>po1.1</code> and return to the configure mode.
PE2(config)#interface xe8	Enter the interface mode for <code>xe8</code> .
PE2(config-if)#speed 10g	Set the speed to 10g.
PE2(config-if)#channel-group 1 mode active	Attach LAG interface <code>po1</code> .
PE2(config-if)#exit	Exit interface mode <code>xe8</code> and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE2: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE2 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

PE2(config)#interface sa2	Enter the single active interface mode for <code>sa2</code> .
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#evpn multi-homed esi 00:00:11:11:77:77 load-balancing single-active	Configure the ESI with the value with the value <code>00:00:11:11:77:77</code> for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE2(config-if-es)#service-carving auto	Configure service carving as <code>auto</code> , allowing automatic determination of service distribution preferences.
PE2(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE2(config-if)#exit	Exit interface mode <code>sa2</code> and return to the configure mode.
PE2(config)#commit	Commit the transaction.
PE2(config)#interface sa2.1 switchport	Create a Layer 2 sub-interface <code>sa2.1</code> within the port channel.
PE2(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE2(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE2(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE2(config-if)#exit	Exit interface mode <code>sa2.1</code> and return to the configure mode.
PE2(config)#interface xe8	Enter the interface mode for <code>xe8</code> .
PE2(config-if)#speed 10g	Set the speed to 10g.
PE2(config-if)#static-channel-group 2	Attach the static-channel-group 2, the LAG interface <code>sa2</code> to <code>xe8</code> .
PE2(config-if)#exit	Exit interface mode <code>xe8</code> and return to the configure mode.
PE2(config)#commit	Commit the transaction.

P1: Loopback Interface

The configuration on P1 for a loopback interface with IP address 10.10.10.5/32 secondary is set up to provide IP connectivity for the router.

P1#configure terminal	Enter configure mode.
P1(config)#interface lo	Enter the interface mode for the loopback interface lo.
P1(config-if)#ip address 10.10.10.5/32 secondary	Configure a secondary IP address, 10.10.10.5/32, on the loopback interface.
P1(config-if)#ip router isis 1	Enable ISIS routing on a loopback interface lo for area 1.
P1(config-if)#prefix-sid index 800	Configure a prefix segment identifier (prefix-SID) index value as 800.
P1(config-if)#exit	Exit interface mode lo.
P1(config)#commit	Commit the transaction.

P1: Configure SR

The following configurations aim to activate Segment Routing (SR) on P1 and make MPLS the preferred method for segment routing, optimizing routing efficiency.

P1(config)#segment-routing	Configure segment routing on P1 device.
P1(config-sr)#mpls sr-prefer	Set MPLS as the preferred segment routing protocol over others.
P1(config-sr)#exit	Exit the router SR mode.
P1(config)#commit	Commit the transaction.

P1: Global LDP

The configuration on P1 for the Global LDP router, specifying router ID and targeted peer, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

P1(config)#router ldp	Enter the Router LDP mode.
P1(config-router)#router-id 10.10.10.5	Set the router ID for LDP to 10.10.10.5.
P1(config-router)#transport-address ipv4 10.10.10.5	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
P1(config-router)#exit	Exit router LDP mode and return to the configure mode.
P1(config)#commit	Commit the transaction.

P1: Interface Configuration

The below configuration is performed to set up interfaces on P1 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

P1(config)#interface xe1	Enter interface mode xe1.
P1(config-if)#ip address 10.1.1.2/30	Configure an IP address, 10.1.1.2/30, on the interface xe1.

P1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P1(config-if)#ip router isis 1	Enable ISIS routing on an interface xe1 for area 1.
P1(config-if)#exit	Exit interface mode xe1.
P1(config)#commit	Commit the transaction.
P1(config)#interface xe2	Enter interface mode xe2.
P1(config-if)#ip address 10.1.4.2/30	Configure an IP address, 10.1.4.2/30, on the interface xe2.
P1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P1(config-if)#ip router isis 1	Enable ISIS routing on an interface xe2 for area 1.
P1(config-if)#exit	Exit interface mode xe2.
P1(config)#commit	Commit the transaction.
P1(config)#interface xe3	Enter interface mode xe3.
P1(config-if)#ip address 10.1.5.2/30	Configure an IP address, 10.1.5.2/30, on the interface xe3.
P1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P1(config-if)#ip router isis 1	Enable ISIS routing on an interface xe3 for area 1.
P1(config-if)#exit	Exit interface mode xe3.
P1(config)#commit	Commit the transaction.
P1(config)#interface xe4	Enter interface mode xe4.
P1(config-if)#ip address 10.1.6.2/30	Configure an IP address, 10.1.6.2/30, on the interface xe4.
P1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P1(config-if)#ip router isis 1	Enable ISIS routing on an interface xe4 for area 1.
P1(config-if)#exit	Exit interface mode xe4.
P1(config)#commit	Commit the transaction.

P1: ISIS Configuration

The below configuration is performed to set up ISIS on P1, to enable MPLS Traffic Engineering, Segment Routing, and other related features for efficient routing and network management.

P1(config)#router isis 1	Enter router ISIS mode.
P1(config-router)#is-type level-1-2	Configure IS-Type as Level-1-2 specifies that the router will participate in both Level-1 and Level-2 areas within the ISIS network.
P1(config-router)#metric-style wide	Configure the new style of metric type as wide.
P1(config-router)#mpls traffic-eng router-id 10.10.10.5	Configure the router's MPLS Traffic Engineering (TE) router ID TLV to 10.10.10.5, which is used for MPLS-TE path calculations.
P1(config-router)#mpls traffic-eng level-1	Enable MPLS-TE for IS-Type Level-1 routing.
P1(config-router)#mpls traffic-eng level-2	Enable MPLS-TE for IS-Type Level-2 routing.
P1(config-router)#capability cspf	Enable Constraint Shortest Path First (CSPF) computation for traffic engineering.
P1(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
P1(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
P1(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
P1(config-router)#bfd all-interfaces	Configure BFD on all interfaces for fast link failure detection.
P1(config-router)#net 49.0000.0000.0005.00	Set a Network Entity Title (NET) for this ISIS instance, specifying the area address and the system ID.
P1(config-router)#isis segment-routing global block 17000 23500	Enable ISIS SR globally and allocates label blocks for Segment Routing.
P1(config-router)#segment-routing mpls	Enable SR ISIS.
P1(config-router)#exit	Exit router ISIS mode and return to the configure mode.
P1(config)#commit	Commit the transaction.

P2: Loopback Interface

The configuration on P2 for a loopback interface with IP address 10.10.10.6/32 secondary is set up to provide IP connectivity for the router.

P2#configure terminal	Enter configure mode.
P2(config)#interface lo	Enter the interface mode for the loopback interface lo.
P2(config-if)#ip address 10.10.10.6/32 secondary	Configure a secondary IP address, 10.10.10.6/32, on the loopback interface.
P2(config-if)#ip router isis 1	Enable ISIS routing on a loopback interface lo for area 1.
P2(config-if)#prefix-sid index 800	Configure a prefix segment identifier (prefix-SID) index value as 800.
P2(config-if)#exit	Exit interface mode lo.
P2(config)#commit	Commit the transaction.

P2: Configure SR

The following configurations aim to activate Segment Routing (SR) on P2 and make MPLS the preferred method for segment routing, optimizing routing efficiency.

P2(config)#segment-routing	Configure segment routing on P2 device.
P2(config-sr)#mpls sr-prefer	Set MPLS as the preferred segment routing protocol over others.
P2(config-sr)#exit	Exit the router SR mode.
P2(config)#commit	Commit the transaction.

P2: Global LDP

The configuration on P2 for the Global LDP router, specifying router ID and targeted peer, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

P2(config)#router ldp	Enter the Router LDP mode.
P2(config-router)#router-id 10.10.10.6	Set the router ID for LDP to 10.10.10.6.
P2(config-router)#transport-address ipv4 10.10.10.6	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
P2(config-router)#exit	Exit router LDP mode and return to the configure mode.
P2(config)#commit	Commit the transaction.

P2: Interface Configuration

The below configuration is performed to set up interfaces on P2 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

P2(config)#interface xe12	Enter interface mode xe12.
P2(config-if)#ip address 10.1.2.2/30	Configure an IP address, 10.1.2.2/30, on the interface xe12.
P2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P2(config-if)#ip router isis 1	Enable ISIS routing on an interface xe12 for area 1.
P2(config-if)#exit	Exit interface mode xe12.
P2(config)#commit	Commit the transaction.
P2(config)#interface xe13	Enter interface mode xe13.
P2(config-if)#ip address 10.1.3.2/30	Configure an IP address, 10.1.3.2/30, on the interface xe13.
P2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P2(config-if)#ip router isis 1	Enable ISIS routing on an interface xe13 for area 1.
P2(config-if)#exit	Exit interface mode xe13.

P2(config)#commit	Commit the transaction.
P2(config)#interface xe11	Enter interface mode xe11.
P2(config-if)#ip address 10.1.7.2/30	Configure an IP address, 10.1.7.2/30, on the interface xe11.
P2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P2(config-if)#ip router isis 1	Enable ISIS routing on an interface xe11 for area 1.
P2(config-if)#exit	Exit interface mode xe11.
P2(config)#commit	Commit the transaction.
P2(config)#interface xe14	Enter interface mode xe14.
P2(config-if)#ip address 10.1.8.2/30	Configure an IP address, 10.1.8.2/30, on the interface xe14.
P2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P2(config-if)#ip router isis 1	Enable ISIS routing on an interface xe14 for area 1.
P2(config-if)#exit	Exit interface mode xe14.
P2(config)#commit	Commit the transaction.

P2: ISIS Configuration

The below configuration is performed to set up ISIS on P2, to enable MPLS Traffic Engineering, Segment Routing, and other related features for efficient routing and network management.

P2(config)#router isis 1	Enter router ISIS mode.
P2(config-router)#is-type level-1-2	Configure IS-Type as Level-1-2 specifies that the router will participate in both Level-1 and Level-2 areas within the ISIS network.
P2(config-router)#metric-style wide	Configure the new style of metric type as wide.
P2(config-router)#mpls traffic-eng router-id 10.10.10.6	Configure the router's MPLS Traffic Engineering (TE) router ID TLV to 10.10.10.6, which is used for MPLS-TE path calculations.
P2(config-router)#mpls traffic-eng level-1	Enable MPLS-TE for IS-Type Level-1 routing.
P2(config-router)#mpls traffic-eng level-2	Enable MPLS-TE for IS-Type Level-2 routing.
P2(config-router)#capability cspf	Enable Constraint Shortest Path First (CSPF) computation for traffic engineering.
P2(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
P2(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
P2(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities

P2(config-router)#bfd all-interfaces	Configure BFD on all interfaces for fast link failure detection.
P2(config-router)#net 49.0000.0000.0006.00	Set a Network Entity Title (NET) for this ISIS instance, specifying the area address and the system ID.
P2(config-router)#isis segment-routing global block 17000 23500	Enable ISIS SR globally and allocates label blocks for Segment Routing.
P2(config-router)#segment-routing mpls	Enable SR ISIS.
P2(config-router)#exit	Exit router ISIS mode and return to the configure mode.
P2(config)#commit	Commit the transaction.

PE3: Loopback Interface

The configuration on PE3 for a loopback interface with IP address 10.10.10.3/32 secondary is set up to provide IP connectivity for the router.

PE3#configure terminal	Enter configure mode.
PE3(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE3(config-if)#ip address 10.10.10.3/32 secondary	Configure a secondary IP address, 10.10.10.3/32, on the loopback interface.
PE3(config-if)#ip router isis 1	Enable ISIS routing on a loopback interface lo for area 1.
PE3(config-if)#prefix-sid index 800	Configure a prefix segment identifier (prefix-SID) index value as 800.
PE3(config-if)#exit	Exit interface mode lo.
PE3(config)#commit	Commit the transaction.

PE3: Configure SR

The following configurations aim to activate Segment Routing (SR) on PE3 and make MPLS the preferred method for segment routing, optimizing routing efficiency.

PE3(config)#segment-routing	Configure segment routing on PE3 device.
PE3(config-sr)#mpls sr-prefer	Set MPLS as the preferred segment routing protocol over others.
PE3(config-sr)#exit	Exit the router SR mode.
PE3(config)#commit	Commit the transaction.

PE3: Global LDP

The configuration on PE3 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE3(config)#router ldp	Enter the Router LDP mode.
PE3(config-router)#router-id 10.10.10.3	Set the router ID for LDP to 10.10.10.3.
PE2(config-router)#transport-address ipv4 10.10.10.3	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.

PE3(config-router)#targeted-peer ipv4 10.10.10.1	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#targeted-peer ipv4 10.10.10.2	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#targeted-peer ipv4 10.10.10.4	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: Global EVPN MPLS Command

The configuration on PE3 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE3(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE3, enabling it to participate in EVPN MPLS services.
PE3(config)#commit	Commit candidate configuration to be running configuration.
PE3(config)#evpn mpls vtep-ip-global 10.10.10.3	Configure the global VTEP IP address 10.10.10.3, associating it with the loopback IP.
PE3(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE3(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE3 to support multi-homed EVPN MPLS services.
PE3(config)#commit	Commit the transaction.

PE3: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE3 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE3(config)#interface xe1	Enter interface mode xe1.
PE3(config-if)#ip address 10.1.6.1/30	Configure an IP address, 10.1.6.1/30, on the interface xe1.
PE3(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE3(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE3(config-if)#ip router isis 1	Enable ISIS routing on an interface xe1 for area 1.
PE3(config-if)#exit	Exit interface mode xe1.
PE3(config)#commit	Commit the transaction.
PE3(config)#interface xe5	Enter interface mode xe5.

PE3(config-if)#ip address 10.1.7.1/30	Configure an IP address, 10.1.7.1/30, on the interface xe5.
PE3(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE3(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE3(config-if)#ip router isis 1	Enable ISIS routing on an interface xe5 for area 1.
PE3(config-if)#exit	Exit interface mode xe5.
PE3(config)#commit	Commit the transaction.

PE3: ISIS Configuration

The below configuration is performed to set up ISIS on PE3, to enable MPLS Traffic Engineering, Segment Routing, and other related features for efficient routing and network management.

PE3(config)#router isis 1	Enter router ISIS mode.
PE3(config-router)#is-type level-1-2	Configure IS-Type as Level-1-2 specifies that the router will participate in both Level-1 and Level-2 areas within the ISIS network.
PE3(config-router)#metric-style wide	Configure the new style of metric type as wide.
PE3(config-router)#mpls traffic-eng router-id 10.10.10.3	Configure the router's MPLS Traffic Engineering (TE) router ID TLV to 10.10.10.3, which is used for MPLS-TE path calculations.
PE3(config-router)#mpls traffic-eng level-1	Enable MPLS-TE for IS-Type Level-1 routing.
PE3(config-router)#mpls traffic-eng level-2	Enable MPLS-TE for IS-Type Level-2 routing.
PE3(config-router)#capability cspf	Enable Constraint Shortest Path First (CSPF) computation for traffic engineering.
PE3(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
PE3(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE3(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE3(config-router)#bfd all-interfaces	Configure BFD on all interfaces for fast link failure detection.
PE3(config-router)#net 49.0000.0000.0003.00	Set a Network Entity Title (NET) for this ISIS instance, specifying the area address and the system ID.
PE3(config-router)#isis segment-routing global block 17000 23500	Enable ISIS SR globally and allocates label blocks for Segment Routing.
PE3(config-router)#segment-routing mpls	Enable SR ISIS.
PE3(config-router)#exit	Exit router ISIS mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: BGP Configuration

The below BGP configuration on PE3 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

PE3(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
PE3(config-router)#bgp router-id 10.10.10.3	Configure BGP router ID 10.10.10.3, identifying PE3 within the BGP network.
PE3(config-router)#neighbor 10.10.10.1 remote-as 65010	Configure neighbor 10.10.10.1 as an iBGP neighbor with their remote AS number 65010.
PE3(config-router)#neighbor 10.10.10.1 update-source lo	Configure neighbor 10.10.10.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 10.10.10.2 remote-as 65010	Configure neighbor 10.10.10.2 as an iBGP neighbor with their remote AS number 65010.
PE3(config-router)#neighbor 10.10.10.2 update-source lo	Configure neighbor 10.10.10.2 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 10.10.10.4 remote-as 65010	Configure neighbor 10.10.10.4 as an iBGP neighbor with their remote AS number 65010.
PE3(config-router)#neighbor 10.10.10.4 update-source lo	Configure neighbor 10.10.10.4 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 10.10.10.1 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE3(config-router)#neighbor 10.10.10.2 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE3(config-router)#neighbor 10.10.10.4 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE3(config-router)#neighbor 10.10.10.1 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE3(config-router)#neighbor 10.10.10.2 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE3(config-router)#neighbor 10.10.10.4 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE3(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE3(config-router-af)#neighbor 10.10.10.1 activate	Activate EVPN for iBGP neighbor 10.10.10.1 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#neighbor 10.10.10.2 activate	Activate EVPN for iBGP neighbor 10.10.10.2 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#neighbor 10.10.10.4 activate	Activate EVPN for iBGP neighbor 10.10.10.4 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE3(config-router)#commit	Commit the transaction.
PE3(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE3: MAC VRF Configuration

The below MAC VRF configuration on PE3 is carried out to define and set up VRFs named `vrf2` and `vp1s1001` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE3(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE3(config-vrf)#rd 10.10.10.3:1700	Configure Route-Distinguisher value of 10.10.10.3:1700.
PE3(config-vrf)#route-target both 1700:1700	Configure import and export values for the vrf2 as 1700:1700.
PE3(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE3(config)#mac vrf vpls1001	Enter VRF mode named vpls1001.
PE3(config-vrf)#rd 10.10.10.3:1001	Configure Route-Distinguisher value of 10.10.10.3:1001.
PE3(config-vrf)#route-target both 1001:1001	Configure import and export values for the vpls1001 as 1001:1001.
PE3(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE3 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

PE3(config)#evpn mpls id 1700 xconnect target-mpls-id 1800	Configure the EVPN-VPWS identifier with a source identifier of 1700 and a target identifier of 1800.
PE3(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE3(config-evpn-mpls)#commit	Commit the transaction.
PE3(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
PE3(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier an identifier of 3000.
PE3(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Map VRF vpls1001 to the EVPN-VPWS identifier
PE3(config-evpn-mpls)#commit	Commit the transaction.
PE3(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE3: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE3 is carried out to configure various parameters including system-MAC, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

PE3(config)#interface po1	Enter the port channel interface mode for po1
PE3(config-if)#load-interval 30	Set the load interval to 30.
PE3(config-if)#evpn multi-homed system-mac 0000.2222.7777 load-balancing port-active	Configure the system-mac address 0000.2222.7777 for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE3(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE3(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE3(config-if)#exit	Exit interface mode po1 and return to the configure mode.

PE3(config)#commit	Commit the transaction.
PE3(config)#interface po1.1 switchport	Create a Layer 2 sub-interface po1.1 within the port channel.
PE3(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE3(config-if)#load-interval 30	Set the load interval to 30.
PE3(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE3(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE3(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE3(config-if)#exit	Exit interface mode po1.1 and return to the configure mode.
PE3(config)#interface xe2	Enter the interface mode for xe2.
PE3(config-if)#speed 10g	Set the speed to 10g.
PE3(config-if)#channel-group 1 mode active	Attach LAG interface po1.
PE3(config-if)#exit	Exit interface mode xe2 and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE3 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

PE3(config)#interface sa1	Enter the single active interface mode for sa1.
PE3(config-if)#load-interval 30	Set the load interval to 30.
PE3(config-if)#evpn multi-homed esi 00:00:22:22:77:77 load-balancing single-active	Configure the ESI with the value with the value 00:00:22:22:77:77 for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE3(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE3(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE3(config-if)#exit	Exit interface mode sa1 and return to the configure mode.
PE3(config)#commit	Commit the transaction.
PE3(config)#interface sa1.1 switchport	Create a Layer 2 sub-interface sa1.1 within the port channel.
PE3(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE3(config-if)#load-interval 30	Set the load interval to 30.
PE3(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE3(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE3(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE3(config-if)#exit	Exit interface mode sa1.1 and return to the configure mode.
PE3(config)#interface xe2	Enter the interface mode for xe2.
PE3(config-if)#speed 10g	Set the speed to 10g.
PE3(config-if)#static-channel-group 1	Attach the static-channel-group 1, the LAG interface sa1 to xe2.

PE3(config-if)#exit	Exit interface mode <code>xe2</code> and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE4: Loopback Interface

The configuration on PE4 for a loopback interface with IP address `10.10.10.4/32` secondary is set up to provide IP connectivity for the router.

PE4#configure terminal	Enter configure mode.
PE4(config)#interface lo	Enter the interface mode for the loopback interface <code>lo</code> .
PE4(config-if)#ip address 10.10.10.4/32 secondary	Configure a secondary IP address, <code>10.10.10.4/32</code> , on the loopback interface.
PE4(config-if)#ip router isis 1	Enable ISIS routing on a loopback interface <code>lo</code> for area 1.
PE4(config-if)#prefix-sid index 800	Configure a prefix segment identifier (prefix-SID) index value as 800.
PE4(config-if)#exit	Exit interface mode <code>lo</code> .
PE4(config)#commit	Commit the transaction.

PE4: Configure SR

The following configurations aim to activate Segment Routing (SR) on PE4 and make MPLS the preferred method for segment routing, optimizing routing efficiency.

PE4(config)#segment-routing	Configure segment routing on PE4 device.
PE4(config-sr)#mpls sr-prefer	Set MPLS as the preferred segment routing protocol over others.
PE4(config-sr)#exit	Exit the router SR mode.
PE4(config)#commit	Commit the transaction.

PE4: Global LDP

The configuration on PE4 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE4(config)#router ldp	Enter the Router LDP mode.
PE4(config-router)#router-id 10.10.10.4	Set the router ID for LDP to <code>10.10.10.4</code> .
PE4(config-router)#transport-address ipv4 10.10.10.4	Configure the transport address for IPv4 (for IPv6 use <code>ipv6</code> parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
PE4(config-router)#targeted-peer ipv4 10.10.10.1	Configure targeted peer for LDP using IPv4 addresses.
PE4(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE4(config-router)#targeted-peer ipv4 10.10.10.2	Configure targeted peer for LDP using IPv4 addresses.
PE4(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.

PE4(config-router)#targeted-peer ipv4 10.10.10.3	Configure targeted peer for LDP using IPv4 addresses.
PE4(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE4(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE4(config)#commit	Commit the transaction.

PE4: Global EVPN MPLS Command

The configuration on PE4 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE4(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE4, enabling it to participate in EVPN MPLS services.
PE4(config)#commit	Commit candidate configuration to be running configuration.
PE4(config)#evpn mpls vtep-ip-global 10.10.10.4	Configure the global VTEP IP address 10.10.10.4, associating it with the loopback IP.
PE4(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE4(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE4 to support multi-homed EVPN MPLS services.
PE4(config)#commit	Commit the transaction.

PE4: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE4 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE4(config)#interface xe2	Enter interface mode xe2.
PE4(config-if)#ip address 10.1.5.1/30	Configure an IP address, 10.1.5.1/30, on the interface xe2.
PE4(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE4(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE4(config-if)#ip router isis 1	Enable ISIS routing on an interface xe2 for area 1.
PE4(config-if)#exit	Exit interface mode xe2.
PE4(config)#commit	Commit the transaction.
PE4(config)#interface xe0	Enter interface mode xe0.
PE4(config-if)#ip address 10.1.8.1/30	Configure an IP address, 10.1.8.1/30, on the interface xe0.
PE4(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE4(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.

PE4(config-if)#ip router isis 1	Enable ISIS routing on an interface xe2 for area 1.
PE4(config-if)#exit	Exit interface mode xe0.
PE4(config)#commit	Commit the transaction.

PE4: ISIS Configuration

The below configuration is performed to set up ISIS on PE4, to enable MPLS Traffic Engineering, Segment Routing, and other related features for efficient routing and network management.

PE4(config)#router isis 1	Enter router ISIS mode.
PE4(config-router)#is-type level-1-2	Configure IS-Type as Level-1-2 specifies that the router will participate in both Level-1 and Level-2 areas within the ISIS network.
PE4(config-router)#metric-style wide	Configure the new style of metric type as wide.
PE4(config-router)#mpls traffic-eng router-id 10.10.10.4	Configure the router's MPLS Traffic Engineering (TE) router ID TLV to 10.10.10.4, which is used for MPLS-TE path calculations.
PE4(config-router)#mpls traffic-eng level-1	Enable MPLS-TE for IS-Type Level-1 routing.
PE4(config-router)#mpls traffic-eng level-2	Enable MPLS-TE for IS-Type Level-2 routing.
PE4(config-router)#capability cspf	Enable Constraint Shortest Path First (CSPF) computation for traffic engineering.
PE4(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
PE4(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE4(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE4(config-router)#bfd all-interfaces	Configure BFD on all interfaces for fast link failure detection.
PE4(config-router)#net 49.0000.0000.0004.00	Set a Network Entity Title (NET) for this ISIS instance, specifying the area address and the system ID.
PE4(config-router)#isis segment-routing global block 17000 23500	Enable ISIS SR globally and allocates label blocks for Segment Routing.
PE4(config-router)#segment-routing mpls	Enable SR ISIS.
PE4(config-router)#exit	Exit router ISIS mode and return to configure mode.
PE4(config)#commit	Commit the transaction.

PE4: BGP Configuration

The below BGP configuration on PE4 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

PE4(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
PE4(config-router)#bgp router-id 10.10.10.4	Configure BGP router ID 10.10.10.4, identifying PE4 within the BGP network.
PE4(config-router)#neighbor 10.10.10.1 remote-as 65010	Configure neighbor 10.10.10.1 as an iBGP neighbor with their remote AS number 65010.

PE4(config-router)#neighbor 10.10.10.1 update-source lo	Configure neighbor 10.10.10.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE4(config-router)#neighbor 10.10.10.2 remote-as 65010	Configure neighbor 10.10.10.2 as an iBGP neighbor with their remote AS number 65010.
PE4(config-router)#neighbor 10.10.10.2 update-source lo	Configure neighbor 10.10.10.2 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE4(config-router)#neighbor 10.10.10.3 remote-as 65010	Configure neighbor 10.10.10.3 as an iBGP neighbor with their remote AS number 65010.
PE4(config-router)#neighbor 10.10.10.3 update-source lo	Configure neighbor 10.10.10.3 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE4(config-router)#neighbor 10.10.10.1 fall- over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE4(config-router)#neighbor 10.10.10.2 fall- over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE4(config-router)#neighbor 10.10.10.3 fall- over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE4(config-router)#neighbor 10.10.10.1 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE4(config-router)#neighbor 10.10.10.2 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE4(config-router)#neighbor 10.10.10.3 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE4(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE4(config-router-af)#neighbor 10.10.10.1 activate	Activate EVPN for iBGP neighbor 10.10.10.1 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE4(config-router-af)#neighbor 10.10.10.2 activate	Activate EVPN for iBGP neighbor 10.10.10.2 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE4(config-router-af)#neighbor 10.10.10.3 activate	Activate EVPN for iBGP neighbor 10.10.10.3 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE4(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE4(config-router)#commit	Commit the transaction.
PE4(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE4: MAC VRF Configuration

The below MAC VRF configuration on PE4 is carried out to define and set up VRFs named `vrf2` and `vp1s1001` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE4(config)#mac vrf vrf2	Enter VRF mode named <code>vrf2</code> .
PE4(config-vrf)#rd 10.10.10.4:1700	Configure Route-Distinguisher value of 10.10.10.4:1700.

PE4(config-vrf)#route-target both 1700:1700	Configure import and export values for the vrf2 as 1700:1700.
PE4(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE4(config)#mac vrf vpls1001	Enter VRF mode named vpls1001.
PE4(config-vrf)#rd 10.10.10.4:1001	Configure Route-Distinguisher value of 10.10.10.4:1001.
PE4(config-vrf)#route-target both 1001:1001	Configure import and export values for the vpls1001 as 1001:1001.
PE4(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE4(config)#commit	Commit the transaction.

PE4: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE4 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

PE4(config)#evpn mpls id 1700 xconnect target-mpls-id 1800	Configure the EVPN-VPWS identifier with a source identifier of 1700 and a target identifier of 1800.
PE4(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE4(config-evpn-mpls)#commit	Commit the transaction.
PE4(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
PE4(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier an identifier of 3000.
PE4(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Map VRF vpls1001 to the EVPN-VPWS identifier
PE4(config-evpn-mpls)#commit	Commit the transaction.
PE4(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE4: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE4 is carried out to configure various parameters including system-MAC, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

PE4(config)#interface po1	Enter the port channel interface mode for po1
PE4(config-if)#load-interval 30	Set the load interval to 30.
PE4(config-if)#evpn multi-homed system-mac 0000.2222.7777 load-balancing port-active	Configure the system-mac address 0000.2222.7777 for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE4(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE4(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE4(config-if)#exit	Exit interface mode po1 and return to the configure mode.
PE4(config)#commit	Commit the transaction.
PE4(config)#interface po1.1 switchport	Create a Layer 2 sub-interface po1.1 within the port channel.
PE4(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.

PE4(config-if)#load-interval 30	Set the load interval to 30.
PE4(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE4(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE4(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE4(config-if)#exit	Exit interface mode <code>po1.1</code> and return to the configure mode.
PE4(config)#interface xe11	Enter the interface mode for <code>xe11</code> .
PE4(config-if)#speed 10g	Set the speed to 10g.
PE4(config-if)#channel-group 1 mode active	Attach LAG interface <code>po1</code> .
PE4(config-if)#exit	Exit interface mode <code>xe11</code> and return to the configure mode.
PE4(config)#commit	Commit the transaction.

PE4: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE4 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

PE4(config)#interface sa2	Enter the single active interface mode for <code>sa2</code> .
PE4(config-if)#load-interval 30	Set the load interval to 30.
PE4(config-if)#evpn multi-homed esi 00:00:22:22:77:77 load-balancing single-active	Configure the ESI with the value with the value <code>00:00:22:22:77:77</code> for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE4(config-if-es)#service-carving auto	Configure service carving as <code>auto</code> , allowing automatic determination of service distribution preferences.
PE4(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE4(config-if)#exit	Exit interface mode <code>sa2</code> and return to the configure mode.
PE4(config)#commit	Commit the transaction.
PE4(config)#interface sa2.1 switchport	Create a Layer 2 sub-interface <code>sa2.1</code> within the port channel.
PE4(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE4(config-if)#load-interval 30	Set the load interval to 30.
PE4(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE4(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE4(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE4(config-if)#exit	Exit interface mode <code>sa2.1</code> and return to the configure mode.
PE4(config)#interface xe11	Enter the interface mode for <code>xe11</code> .
PE4(config-if)#speed 10g	Set the speed to 10g.
PE4(config-if)#static-channel-group 2	Attach the static-channel-group 2, the LAG interface <code>sa2</code> to <code>xe11</code> .
PE4(config-if)#exit	Exit interface mode <code>xe11</code> and return to the configure mode.
PE4(config)#commit	Commit the transaction.

CE2

The following configuration steps under CE2 are set up to enable VLANs and configure interfaces for carrying VLAN traffic.

CE2#configure terminal	Enter configure mode.
CE2(config)#bridge 1 protocol ieee vlan-bridge	Set up bridge 1 to use the IEEE VLAN bridge protocol.
CE2(config)#vlan 2-100 bridge 1 state enable	Configure VLANs from 2-100 and associate them with bridge 1.
CE2(config)#interface xe24	Enter interface mode xe24.
CE2(config-if)#switchport	Configure the interface xe24 as a Layer 2 switch port.
CE2(config-if)#bridge-group 1	Associate xe24 to bridge 1.
CE2(config-if)#switchport mode trunk	Configure xe24 as a trunk port.
CE2(config-if)#switchport trunk allowed vlan all	Allow all configured VLANs on the trunk interface xe24.
CE2(config-if)#exit	Exit interface mode xe24.
CE2(config)#interface po1	Enter interface mode and configure LAG interface port-channel 1 (po1).
CE2(config-if)#switchport	Configures port-channel 1 as a Layer 2 switch port.
CE2(config-if)#bridge-group 1	Associate po1 to bridge 1.
CE2(config-if)#switchport mode trunk	Configure po1 as a trunk port.
CE2(config-if)#switchport trunk allowed vlan all	Allow all configured VLANs on the trunk port-channel po1.
CE2(config-if)#exit	Exit interface mode po1.
CE2(config)#interface xe22	Enter interface mode xe22.
CE2(config-if)#lacp timeout short	Configure LACP timeout as short.
CE2(config-if)#channel-group 1 mode active	Add member to the LAG interface.
CE2(config-if)#exit	Exit interface mode xe22.
CE2(config-if)#interface xe23	Enter interface mode xe23.
CE2(config-if)#lacp timeout short	Configure LACP timeout as short.
CE2(config-if)#channel-group 1 mode active	Add member to the LAG interface.
CE2(config-if)#commit	Commit the transaction.
CE2(config-if)#end	Exit interface mode xe23 and configure mode.

EVPN SR Active-Standby MH Validation

This section provides show outputs validation for port-active mode, covering ELINE and ELAN services with SR as the underlay MPLS path.

The following show output displays the forwarding table entries on PE1, PE2, PE3, and PE4 devices in the network [Figure 3-8](#) using the **show mpls forwarding-table** command.

```
PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP
```

FTN-ECMP LDP: Disabled

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
i>	10.10.10.2/32	1	4	0	Yes	LSP_DEFAULT	17700	xe2	No	10.1.2.2
i>	10.10.10.2/32	10	23	0	No	LSP_DEFAULT	3	xe1	No	10.1.1.2
i(b)>	10.10.10.2/32	6	17	2201	Yes	LSP_DEFAULT	17700	xe1	No	10.1.1.2
i>	10.10.10.3/32	2	6	0	Yes	LSP_DEFAULT	17400	xe2	No	10.1.2.2
i>	10.10.10.3/32	11	24	0	No	LSP_DEFAULT	3	xe1	No	10.1.1.2
i(b)>	10.10.10.3/32	7	19	2202	Yes	LSP_DEFAULT	17400	xe1	No	10.1.1.2
i(b)>	10.10.10.3/32	9	22	2204	Yes	LSP_DEFAULT	17400	xe2	No	10.1.2.2
i>	10.10.10.4/32	3	8	0	Yes	LSP_DEFAULT	17300	xe2	No	10.1.2.2
i>	10.10.10.4/32	12	25	0	No	LSP_DEFAULT	3	xe1	No	10.1.1.2
i(b)>	10.10.10.4/32	8	21	2203	Yes	LSP_DEFAULT	17300	xe1	No	10.1.1.2
i>	10.10.10.5/32	4	9	0	Yes	LSP_DEFAULT	3	xe1	No	10.1.1.2
i>	10.10.10.5/32	13	27	0	No	LSP_DEFAULT	17600	xe2	No	10.1.2.2
i>	10.10.10.6/32	5	15	0	Yes	LSP_DEFAULT	3	xe2	No	10.1.2.2
i>	10.10.10.6/32	14	29	0	No	LSP_DEFAULT	17500	xe1	No	10.1.1.2

PE2#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
 (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
i>	10.10.10.1/32	1	10	0	Yes	LSP_DEFAULT	17800	xe4	No	10.1.3.2
i>	10.10.10.1/32	10	27	0	No	LSP_DEFAULT	3	xe5	No	10.1.4.2
i(b)>	10.10.10.1/32	6	21	2201	Yes	LSP_DEFAULT	17800	xe5	No	10.1.4.2
i>	10.10.10.3/32	2	11	0	Yes	LSP_DEFAULT	17400	xe4	No	10.1.3.2
i>	10.10.10.3/32	11	28	0	No	LSP_DEFAULT	3	xe5	No	10.1.4.2
i(b)>	10.10.10.3/32	7	23	2202	Yes	LSP_DEFAULT	17400	xe5	No	10.1.4.2
i(b)>	10.10.10.3/32	9	26	2204	Yes	LSP_DEFAULT	17400	xe4	No	10.1.3.2
i>	10.10.10.4/32	3	12	0	Yes	LSP_DEFAULT	17300	xe4	No	10.1.3.2
i>	10.10.10.4/32	12	29	0	No	LSP_DEFAULT	3	xe5	No	10.1.4.2
i(b)>	10.10.10.4/32	8	25	2203	Yes	LSP_DEFAULT	17300	xe5	No	10.1.4.2
i>	10.10.10.5/32	4	13	0	Yes	LSP_DEFAULT	3	xe5	No	10.1.4.2
i>	10.10.10.5/32	13	31	0	No	LSP_DEFAULT	17600	xe4	No	10.1.3.2
i>	10.10.10.6/32	5	19	0	Yes	LSP_DEFAULT	3	xe4	No	10.1.3.2
i>	10.10.10.6/32	14	33	0	No	LSP_DEFAULT	17500	xe5	No	10.1.4.2

PE3#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
 (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
i>	10.10.10.1/32	1	4	0	Yes	LSP_DEFAULT	17800	xe5	No	10.1.7.2
i>	10.10.10.1/32	10	23	0	No	LSP_DEFAULT	3	xe1	No	10.1.6.2
i(b)>	10.10.10.1/32	6	17	2201	Yes	LSP_DEFAULT	17800	xe1	No	10.1.6.2
i(b)>	10.10.10.1/32	9	22	2204	Yes	LSP_DEFAULT	17800	xe5	No	10.1.7.2
i>	10.10.10.2/32	2	6	0	Yes	LSP_DEFAULT	17700	xe5	No	10.1.7.2
i>	10.10.10.2/32	11	24	0	No	LSP_DEFAULT	3	xe1	No	10.1.6.2
i(b)>	10.10.10.2/32	7	19	2202	Yes	LSP_DEFAULT	17700	xe1	No	10.1.6.2
i>	10.10.10.4/32	3	8	0	Yes	LSP_DEFAULT	17300	xe5	No	10.1.7.2
i>	10.10.10.4/32	12	25	0	No	LSP_DEFAULT	3	xe1	No	10.1.6.2
i(b)>	10.10.10.4/32	8	21	2203	Yes	LSP_DEFAULT	17300	xe1	No	10.1.6.2
i>	10.10.10.5/32	4	9	0	Yes	LSP_DEFAULT	3	xe1	No	10.1.6.2
i>	10.10.10.5/32	13	27	0	No	LSP_DEFAULT	17600	xe5	No	10.1.7.2
i>	10.10.10.6/32	5	15	0	Yes	LSP_DEFAULT	3	xe5	No	10.1.7.2
i>	10.10.10.6/32	14	29	0	No	LSP_DEFAULT	17500	xe1	No	10.1.6.2

PE4#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
 (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
i>	10.10.10.1/32	1	4	0	Yes	LSP_DEFAULT	17800	xe0	No	10.1.8.2
i>	10.10.10.1/32	10	23	0	No	LSP_DEFAULT	3	xe2	No	10.1.5.2
i(b)>	10.10.10.1/32	6	17	2201	Yes	LSP_DEFAULT	17800	xe2	No	10.1.5.2
i>	10.10.10.2/32	2	6	0	Yes	LSP_DEFAULT	17700	xe0	No	10.1.8.2
i>	10.10.10.2/32	11	24	0	No	LSP_DEFAULT	3	xe2	No	10.1.5.2
i(b)>	10.10.10.2/32	7	19	2202	Yes	LSP_DEFAULT	17700	xe2	No	10.1.5.2
i>	10.10.10.3/32	3	8	0	Yes	LSP_DEFAULT	17400	xe0	No	10.1.8.2
i>	10.10.10.3/32	12	25	0	No	LSP_DEFAULT	3	xe2	No	10.1.5.2
i(b)>	10.10.10.3/32	8	21	2203	Yes	LSP_DEFAULT	17400	xe2	No	10.1.5.2
i(b)>	10.10.10.3/32	9	22	2204	Yes	LSP_DEFAULT	17400	xe0	No	10.1.8.2
i>	10.10.10.5/32	4	9	0	Yes	LSP_DEFAULT	3	xe2	No	10.1.5.2
i>	10.10.10.5/32	13	27	0	No	LSP_DEFAULT	17600	xe0	No	10.1.8.2
i>	10.10.10.6/32	5	15	0	Yes	LSP_DEFAULT	3	xe0	No	10.1.8.2
i>	10.10.10.6/32	14	29	0	No	LSP_DEFAULT	17500	xe2	No	10.1.5.2

The following show output displays the FEC-To-NHLF (FTN) table information on PE1, PE2, PE3, and PE4 devices in the network [Figure 3-8](#) using the **show mpls ftn-table** command.

PE1#show mpls ftn-table

```
Primary FTN entry with FEC: 10.10.10.2/32, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
  Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 12
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 12, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17700
  Nexthop addr: 10.1.2.2      cross connect ix: 7, op code: Push
```

```
Non-primary FTN entry with FEC: 10.10.10.2/32, id: 10, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
  Nexthop addr: 10.1.1.2      cross connect ix: 2, op code: Push
```

bypass_ftn_ix 6

```
Primary FTN entry with FEC: 10.10.10.2/32, id: 6, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2201, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 16
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 16, owner: ISIS-SR, Stale: NO, out intf: xe1, out label: 17700
  Nexthop addr: 10.1.1.2      cross connect ix: 5, op code: Push
```

```
Primary FTN entry with FEC: 10.10.10.3/32, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
  Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 13
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 13, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17400
  Nexthop addr: 10.1.2.2      cross connect ix: 3, op code: Push
```

```
Non-primary FTN entry with FEC: 10.10.10.3/32, id: 11, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
  Nexthop addr: 10.1.1.2      cross connect ix: 2, op code: Push
```

bypass_ftn_ix 7

```
Primary FTN entry with FEC: 10.10.10.3/32, id: 7, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2202, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 18
```

Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 18, owner: ISIS-SR, Stale: NO, out intf: xe1, out label: 17400
Nexthop addr: 10.1.1.2 cross connect ix: 8, op code: Push

Primary FTN entry with FEC: 10.10.10.3/32, id: 9, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2204, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 13
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 13, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17400
Nexthop addr: 10.1.2.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 10.10.10.4/32, id: 3, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 14
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 14, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17300
Nexthop addr: 10.1.2.2 cross connect ix: 4, op code: Push

Non-primary FTN entry with FEC: 10.10.10.4/32, id: 12, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 10.1.1.2 cross connect ix: 2, op code: Push

bypass_ftn_ix 8

Primary FTN entry with FEC: 10.10.10.4/32, id: 8, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2203, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 20
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 20, owner: ISIS-SR, Stale: NO, out intf: xe1, out label: 17300
Nexthop addr: 10.1.1.2 cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 10.10.10.5/32, id: 4, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 10.1.1.2 cross connect ix: 2, op code: Push

Non-primary FTN entry with FEC: 10.10.10.5/32, id: 13, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 26
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 26, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe2, transport out intf: N/A, out label: 17600
Nexthop addr: 10.1.2.2 cross connect ix: 10, op code: Push and Lookup

bypass_ftn_ix 9

Primary FTN entry with FEC: 10.10.10.6/32, id: 5, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 11
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 11, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 10.1.2.2 cross connect ix: 6, op code: Push

Non-primary FTN entry with FEC: 10.10.10.6/32, id: 14, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0

```

Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 28
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 28, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe1, transport out intf: N/A, out label: 17500
Nexthop addr: 10.1.1.2      cross connect ix: 11, op code: Push and Lookup

bypass_ftn_ix 7

PE2#show mpls ftn-table
Primary FTN entry with FEC: 10.10.10.1/32, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 16
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 16, owner: ISIS-SR, Stale: NO, out intf: xe4, out label: 17800
Nexthop addr: 10.1.3.2      cross connect ix: 7, op code: Push

Non-primary FTN entry with FEC: 10.10.10.1/32, id: 10, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe5, out label: 3
Nexthop addr: 10.1.4.2      cross connect ix: 2, op code: Push

bypass_ftn_ix 6

Primary FTN entry with FEC: 10.10.10.1/32, id: 6, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2201, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 20
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 20, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17800
Nexthop addr: 10.1.4.2      cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.10.10.3/32, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 17
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 17, owner: ISIS-SR, Stale: NO, out intf: xe4, out label: 17400
Nexthop addr: 10.1.3.2      cross connect ix: 3, op code: Push

Non-primary FTN entry with FEC: 10.10.10.3/32, id: 11, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe5, out label: 3
Nexthop addr: 10.1.4.2      cross connect ix: 2, op code: Push

bypass_ftn_ix 7

Primary FTN entry with FEC: 10.10.10.3/32, id: 7, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2202, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 22
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 22, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17400
Nexthop addr: 10.1.4.2      cross connect ix: 8, op code: Push

Primary FTN entry with FEC: 10.10.10.3/32, id: 9, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2204, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 17
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 17, owner: ISIS-SR, Stale: NO, out intf: xe4, out label: 17400
Nexthop addr: 10.1.3.2      cross connect ix: 3, op code: Push

```

Primary FTN entry with FEC: 10.10.10.4/32, id: 3, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
 Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 18
 Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 18, owner: ISIS-SR, Stale: NO, out intf: xe4, out label: 17300
 Nexthop addr: 10.1.3.2 cross connect ix: 4, op code: Push

Non-primary FTN entry with FEC: 10.10.10.4/32, id: 12, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
 Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
 Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe5, out label: 3
 Nexthop addr: 10.1.4.2 cross connect ix: 2, op code: Push

bypass_ftn_ix 8

Primary FTN entry with FEC: 10.10.10.4/32, id: 8, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 2203, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
 Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 24
 Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 24, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17300
 Nexthop addr: 10.1.4.2 cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 10.10.10.5/32, id: 4, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
 Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
 Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe5, out label: 3
 Nexthop addr: 10.1.4.2 cross connect ix: 2, op code: Push

Non-primary FTN entry with FEC: 10.10.10.5/32, id: 13, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
 Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 30
 Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 30, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe4, transport out intf: N/A, out label: 17600
 Nexthop addr: 10.1.3.2 cross connect ix: 10, op code: Push and Lookup

bypass_ftn_ix 9

Primary FTN entry with FEC: 10.10.10.6/32, id: 5, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
 Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 15
 Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 15, owner: N/A, Stale: NO, out intf: xe4, out label: 3
 Nexthop addr: 10.1.3.2 cross connect ix: 6, op code: Push

Non-primary FTN entry with FEC: 10.10.10.6/32, id: 14, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
 Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 32
 Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 32, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe5, transport out intf: N/A, out label: 17500
 Nexthop addr: 10.1.4.2 cross connect ix: 11, op code: Push and Lookup

bypass_ftn_ix 7

PE3#show mpls ftn-table

Primary FTN entry with FEC: 10.10.10.1/32, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
 Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 12
 Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 12, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17800

NextHop addr: 10.1.7.2 cross connect ix: 7, op code: Push

Non-primary FTN entry with FEC: 10.10.10.1/32, id: 10, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
NextHop addr: 10.1.6.2 cross connect ix: 2, op code: Push

bypass_ftn_ix 6

Primary FTN entry with FEC: 10.10.10.1/32, id: 6, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2201, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 16
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 16, owner: ISIS-SR, Stale: NO, out intf: xe1, out label: 17800
NextHop addr: 10.1.6.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.10.10.1/32, id: 9, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2204, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 12
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 12, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17800
NextHop addr: 10.1.7.2 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 10.10.10.2/32, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 13
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 13, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17700
NextHop addr: 10.1.7.2 cross connect ix: 3, op code: Push

Non-primary FTN entry with FEC: 10.10.10.2/32, id: 11, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
NextHop addr: 10.1.6.2 cross connect ix: 2, op code: Push

bypass_ftn_ix 7

Primary FTN entry with FEC: 10.10.10.2/32, id: 7, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2202, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 18
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 18, owner: ISIS-SR, Stale: NO, out intf: xe1, out label: 17700
NextHop addr: 10.1.6.2 cross connect ix: 8, op code: Push

Primary FTN entry with FEC: 10.10.10.4/32, id: 3, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 14
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 14, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17300
NextHop addr: 10.1.7.2 cross connect ix: 4, op code: Push

Non-primary FTN entry with FEC: 10.10.10.4/32, id: 12, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

```

    Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.1.6.2          cross connect ix: 2, op code: Push

bypass_ftn_ix 8

Primary FTN entry with FEC: 10.10.10.4/32, id: 8, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2203, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 20
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 20, owner: ISIS-SR, Stale: NO, out intf: xe1, out label: 17300
    Nexthop addr: 10.1.6.2          cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 10.10.10.5/32, id: 4, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
  Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.1.6.2          cross connect ix: 2, op code: Push

Non-primary FTN entry with FEC: 10.10.10.5/32, id: 13, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 26
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 26, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe5, transport out intf: N/A, out label: 17600
    Nexthop addr: 10.1.7.2          cross connect ix: 10, op code: Push and Lookup

bypass_ftn_ix 9

Primary FTN entry with FEC: 10.10.10.6/32, id: 5, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
  Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 11
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 11, owner: N/A, Stale: NO, out intf: xe5, out label: 3
    Nexthop addr: 10.1.7.2          cross connect ix: 6, op code: Push

Non-primary FTN entry with FEC: 10.10.10.6/32, id: 14, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 28
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 28, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe1, transport out intf: N/A, out label: 17500
    Nexthop addr: 10.1.6.2          cross connect ix: 11, op code: Push and Lookup

bypass_ftn_ix 7

PE4#show mpls ftn-table
Primary FTN entry with FEC: 10.10.10.1/32, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
  Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 12
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 12, owner: ISIS-SR, Stale: NO, out intf: xe0, out label: 17800
    Nexthop addr: 10.1.8.2          cross connect ix: 7, op code: Push

Non-primary FTN entry with FEC: 10.10.10.1/32, id: 10, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 10.1.5.2          cross connect ix: 2, op code: Push

bypass_ftn_ix 6

Primary FTN entry with FEC: 10.10.10.1/32, id: 6, row status: Active, Tunnel-Policy: N/A, State: Installed

```

Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2201, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 16
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 16, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17800
Nexthop addr: 10.1.5.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.10.10.2/32, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 13
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 13, owner: ISIS-SR, Stale: NO, out intf: xe0, out label: 17700
Nexthop addr: 10.1.8.2 cross connect ix: 3, op code: Push

Non-primary FTN entry with FEC: 10.10.10.2/32, id: 11, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 10.1.5.2 cross connect ix: 2, op code: Push

bypass_ftn_ix 7

Primary FTN entry with FEC: 10.10.10.2/32, id: 7, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2202, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 18
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 18, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17700
Nexthop addr: 10.1.5.2 cross connect ix: 8, op code: Push

Primary FTN entry with FEC: 10.10.10.3/32, id: 3, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 14
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 14, owner: ISIS-SR, Stale: NO, out intf: xe0, out label: 17400
Nexthop addr: 10.1.8.2 cross connect ix: 4, op code: Push

Non-primary FTN entry with FEC: 10.10.10.3/32, id: 12, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 10.1.5.2 cross connect ix: 2, op code: Push

bypass_ftn_ix 8

Primary FTN entry with FEC: 10.10.10.3/32, id: 8, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2203, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 20
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 20, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17400
Nexthop addr: 10.1.5.2 cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 10.10.10.3/32, id: 9, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 2204, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 14
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 14, owner: ISIS-SR, Stale: NO, out intf: xe0, out label: 17400
Nexthop addr: 10.1.8.2 cross connect ix: 4, op code: Push

```

Primary FTN entry with FEC: 10.10.10.5/32, id: 4, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
  Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
  Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 10.1.5.2      cross connect ix: 2, op code: Push

Non-primary FTN entry with FEC: 10.10.10.5/32, id: 13, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 26
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 26, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe0, transport out intf: N/A, out label: 17600
Nexthop addr: 10.1.8.2      cross connect ix: 10, op code: Push and Lookup

bypass_ftn_ix 9

Primary FTN entry with FEC: 10.10.10.6/32, id: 5, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
  Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 11
  Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 11, owner: N/A, Stale: NO, out intf: xe0, out label: 3
Nexthop addr: 10.1.8.2      cross connect ix: 6, op code: Push

Non-primary FTN entry with FEC: 10.10.10.6/32, id: 14, row status: Active, Tunnel-Policy: N/A, State: Installed
Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 28
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 28, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe2, transport out intf: N/A, out label: 17500
Nexthop addr: 10.1.5.2      cross connect ix: 11, op code: Push and Lookup

bypass_ftn_ix 8

```

Port-Active

The following show output displays the Ethernet Segment (ES) and Intermediate System (IS) neighbor adjacencies for PE1, PE2, PE3, PE4, P1, and P2 devices in the network [Figure 3-8](#) using the **show clns neighbors** command.

```
PE1#show clns neighbors
```

```

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 2
Total number of adjacencies: 4
Tag 1: VRF : default
System Id      Interface  SNPA              State Holdtime  Type Protocol
P2             xe2       e8c5.7a55.3c7e    Up    22        L1   IS-IS
               Up        22              L2   IS-IS
P1             xe1       e49d.73b3.c107    Up    23        L1   IS-IS

```

```
PE2#show clns neighbors
```

```

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 2
Total number of adjacencies: 4
Tag 1: VRF : default
System Id      Interface  SNPA              State Holdtime  Type Protocol
P2             xe4       e8c5.7a55.3c7f    Up    8         L1   IS-IS
               Up        8              L2   IS-IS
P1             xe5       e49d.73b3.c14c    Up    29        L1   IS-IS
               Up        29              L2   IS-IS
               Up        23              L2   IS-IS

```

```
P1#show clns neighbors
```

```

Total number of L1 adjacencies: 4
Total number of L2 adjacencies: 4
Total number of adjacencies: 8

```

```

Tag 1: VRF : default
System Id      Interface  SNPA                State Holdtime Type Protocol
PE3            xe4        b86a.97d9.2cdf      Up    19      L1    IS-IS
                Up    19      L2    IS-IS
PE2            xe2        e8c5.7a47.9dfc      Up    7       L1    IS-IS
                Up    7       L2    IS-IS
PE1            xe1        e8c5.7a78.c918      Up    7       L1    IS-IS
                Up    7       L2    IS-IS
PE4            xe3        d077.ceda.7004      Up    19      L1    IS-IS
                Up    19      L2    IS-IS

```

P2#show clns neighbors

```

Total number of L1 adjacencies: 4
Total number of L2 adjacencies: 4
Total number of adjacencies: 8

```

```

Tag 1: VRF : default
System Id      Interface  SNPA                State Holdtime Type Protocol
PE3            xe11       b86a.97d9.2ccb      Up    19      L1    IS-IS
                Up    19      L2    IS-IS
PE1            xe12       e8c5.7a78.c908      Up    7       L1    IS-IS
                Up    7       L2    IS-IS
PE2            xe13       e8c5.7a47.9dfb      Up    19      L1    IS-IS
                Up    19      L2    IS-IS
PE4            xe14       d077.ceda.7002      Up    19      L1    IS-IS
                Up    19      L2    IS-IS

```

PE3#show clns neighbors

```

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 2
Total number of adjacencies: 4

```

```

Tag 1: VRF : default
System Id      Interface  SNPA                State Holdtime Type Protocol
P2             xe5        e8c5.7a55.3c77      Up    7       L1    IS-IS
                Up    7       L2    IS-IS
P1             xe1        e49d.73b3.c105      Up    5       L1    IS-IS
                Up    5       L2    IS-IS

```

PE4#show clns neighbors

```

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 2
Total number of adjacencies: 4

```

```

Tag 1: VRF : default
System Id      Interface  SNPA                State Holdtime Type Protocol
P2             xe0        e8c5.7a55.3c80      Up    5       L1    IS-IS
                Up    5       L2    IS-IS
P1             xe2        e49d.73b3.c14d      Up    6       L1    IS-IS
                Up    6       L2    IS-IS

```

Port-Active ELAN

The following show outputs provide validation for ELAN configurations.

The following show output displays the EVPN active multi-homed and load-balanced details on PE1, PE2, PE3, and PE4 devices in the network [Figure 3-8](#) using the **show evpn load-balance port-active** and **show evpn multi-homing all** commands.

```

PE1#show evpn load-balance port-active
ESI              AC-IF/PE  PE-IP-ADDRESS  Redundancy  Service-carving  weight  Revertive  AC-DF
Status
=====
00:00:00:11:11:77:77:00:00:00  LOCAL    10.10.10.1     port-active  auto             0       NO         NA
STANDBY
00:00:00:11:11:77:77:00:00:00  REMOTE    10.10.10.2     port-active  auto             0       NO         NA
ACTIVE
00:00:00:22:22:77:77:00:00:00  REMOTE    10.10.10.3     port-active  ----            ----     ----     ----
STANDBY
00:00:00:22:22:77:77:00:00:00  REMOTE    10.10.10.4     port-active  ----            ----     ----     ----
ACTIVE

```

```

PE2#show evpn load-balance port-active
ESI                               AC-IF/PE    PE-IP-ADDRESS  Redundancy    Service-carving  weight  Revertive  AC-DF
Status
=====
00:00:00:11:11:77:77:00:00:00  REMOTE     10.10.10.1     port-active    auto             0       NO         NA
STANDBY
00:00:00:11:11:77:77:00:00:00  LOCAL      10.10.10.2     port-active    auto             0       NO         NA
ACTIVE
00:00:00:22:22:77:77:00:00:00  REMOTE     10.10.10.3     port-active    ----            ----    ----    ----
STANDBY
00:00:00:22:22:77:77:00:00:00  REMOTE     10.10.10.4     port-active    ----            ----    ----    ----
ACTIVE

PE3#show evpn load-balance port-active
ESI                               AC-IF/PE    PE-IP-ADDRESS  Redundancy    Service-carving  weight  Revertive  AC-DF
Status
=====
00:00:00:11:11:77:77:00:00:00  REMOTE     10.10.10.1     port-active    ----            ----    ----    ----
STANDBY
00:00:00:11:11:77:77:00:00:00  REMOTE     10.10.10.2     port-active    ----            ----    ----    ----
ACTIVE
00:00:00:22:22:77:77:00:00:00  LOCAL      10.10.10.3     port-active    auto            0       NO         NA
STANDBY
00:00:00:22:22:77:77:00:00:00  REMOTE     10.10.10.4     port-active    auto            0       NO         NA
ACTIVE

PE4#show evpn load-balance port-active
ESI                               AC-IF/PE    PE-IP-ADDRESS  Redundancy    Service-carving  weight  Revertive  AC-DF
Status
=====
00:00:00:11:11:77:77:00:00:00  REMOTE     10.10.10.1     port-active    ----            ----    ----    ----
STANDBY
00:00:00:11:11:77:77:00:00:00  REMOTE     10.10.10.2     port-active    ----            ----    ----    ----
ACTIVE
00:00:00:22:22:77:77:00:00:00  REMOTE     10.10.10.3     port-active    auto            0       NO         NA
STANDBY
00:00:00:22:22:77:77:00:00:00  LOCAL      10.10.10.4     port-active    auto            0       NO         NA
ACTIVE

PE1#show evpn multi-homing all
ESI                               Access-IF    PE-IP-ADDRESS
=====
00:00:00:11:11:77:77:00:00:00  po1         10.10.10.1
00:00:00:11:11:77:77:00:00:00  ----        10.10.10.2
00:00:00:22:22:77:77:00:00:00  ----        10.10.10.3
00:00:00:22:22:77:77:00:00:00  ----        10.10.10.4
Total number of entries are 4

PE2#show evpn multi-homing all
ESI                               Access-IF    PE-IP-ADDRESS
=====
00:00:00:11:11:77:77:00:00:00  ----        10.10.10.1
00:00:00:11:11:77:77:00:00:00  po1         10.10.10.2
00:00:00:22:22:77:77:00:00:00  ----        10.10.10.3
00:00:00:22:22:77:77:00:00:00  ----        10.10.10.4
Total number of entries are 4

PE3#show evpn multi-homing all
ESI                               Access-IF    PE-IP-ADDRESS
=====
00:00:00:11:11:77:77:00:00:00  ----        10.10.10.1
00:00:00:11:11:77:77:00:00:00  ----        10.10.10.2
00:00:00:22:22:77:77:00:00:00  po1         10.10.10.3
00:00:00:22:22:77:77:00:00:00  ----        10.10.10.4
Total number of entries are 4

PE4#show evpn multi-homing all
ESI                               Access-IF    PE-IP-ADDRESS
=====
00:00:00:11:11:77:77:00:00:00  ----        10.10.10.1
00:00:00:11:11:77:77:00:00:00  ----        10.10.10.2
00:00:00:22:22:77:77:00:00:00  ----        10.10.10.3

```

```
00:00:00:22:22:77:77:00:00:00 po1 10.10.10.4
Total number of entries are 4
```

The following show output displays the active EVPN MPLS Tunnels for ELAN on PE1, PE2, PE3, and PE4 devices in the network [Figure 3-7](#) using the **show evpn mpls tunnel** command.

```
PE1#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      evpn-id
=====
10.10.10.1   10.10.10.2       Installed   00:02:19     00:02:19     3000
10.10.10.1   10.10.10.4       Installed   00:10:21     00:10:21     3000
10.10.10.1   10.10.10.3       Installed   00:10:47     00:10:47     3000
```

Total number of entries are 3

```
PE2#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      evpn-id
=====
10.10.10.2   10.10.10.1       Installed   00:02:01     00:02:01     3000
10.10.10.2   10.10.10.4       Installed   00:02:01     00:02:01     3000
10.10.10.2   10.10.10.3       Installed   00:02:01     00:02:01     3000
```

Total number of entries are 3

```
PE3#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      evpn-id
=====
10.10.10.3   10.10.10.2       Installed   00:02:27     00:02:27     3000
10.10.10.3   10.10.10.4       Installed   00:10:29     00:10:29     3000
10.10.10.3   10.10.10.1       Installed   00:10:54     00:10:54     3000
```

Total number of entries are 3

```
PE4#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      evpn
-id
=====
10.10.10.4   10.10.10.2       Installed   00:02:30     00:02:30     3000
10.10.10.4   10.10.10.3       Installed   00:10:32     00:10:32     3000
10.10.10.4   10.10.10.1       Installed   00:10:32     00:10:32     3000
```

Total number of entries are 3

Port-Active ELINE

The following show output displays the active EVPN SR Tunnels for ELINE on PE1, PE2, PE3, and PE4 devices in the network [Figure 3-8](#) using the **show evpn mpls xconnect tunnel** command.

```
PE1#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
10.10.10.1   10.10.10.4       AC-Down     01:07:01     01:07:01     1800         1700
10.10.10.1   10.10.10.3       AC-Down     01:07:01     01:07:01     1800         1700
```

Total number of entries are 2

```
PE2#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
10.10.10.2   10.10.10.3       Installed   00:08:20     00:07:31     1800         1700
10.10.10.2   10.10.10.4       Installed   00:08:20     00:07:31     1800         1700
```

Total number of entries are 2

```
PE3#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	local-evpn-id	remote-evpn-id
10.10.10.3	10.10.10.1	AC-Down	01:04:48	01:04:48	1700	1800
10.10.10.3	10.10.10.2	AC-Down	00:08:48	00:08:48	1700	1800

Total number of entries are 2

```
PE4#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	local-evpn-id	remote-evpn-id
10.10.10.4	10.10.10.1	Installed	00:09:00	00:08:28	1700	1800
10.10.10.4	10.10.10.2	Installed	00:09:01	00:08:28	1700	1800

Total number of entries are 2

Implementation Examples

Scenario: Customer wants to achieve redundancy for its hosts in a network using Single-Active or Port-Active redundancy.

- Customer configures the `evpn multi-homed` command with the `load-balancing single-active` or `load-balancing port-active` option on the relevant PE interfaces.
- Single-Active or Port-Active redundancy is now in effect, ensuring redundancy for hosts.
- The feature works in conjunction with other EVPN-related configurations, such as VRF, VLAN mapping, and other EVPN settings.

New CLI Commands

The EVPN Active-Standby feature introduces the following configuration commands. For more information of the EVPN MPLS commands, see the [EVPN MPLS Commands](#) chapter in the *Multi-Protocol Label Switching Guide*.

service-carving ac-driven

Use this command to enable the AC-influenced method for any selected Designated Forwarder (DF) algorithm.

Enabling the `ac-driven` method allows the Designated Forwarder (DF) algorithm to be influenced by the Attachment Circuits (AC's) associated with a specific Ethernet Segment (ES). This means that the DF selection is based on the AC's characteristics and conditions, such as whether an AC is operational UP, mapped, or unmapped on the ESI.

Use `no` form of this command to disable the AC-influenced method for any selected Designated Forwarder (DF) algorithm.

Command Syntax

```
service-carving ac-driven
no service-carving ac-driven
```

Parameters

None

Default

ac-driven is disabled.

Command Mode

EVPN Ethernet Segment (ES) Mode

Applicability

This command was introduced in the OcNOS version 6.4.2.

Example

The provided examples showcase the configuration of the `service-carving ac-driven` command in EVPN Ethernet Segment (ES) mode. The first two examples demonstrate enabling this feature with different DF election methods, and the final example illustrates the command to disable `service-carving ac-driven`.

```
OcNOS#configure terminal
OcNOS(config)#interface sa1
OcNOS(config-if)#evpn multi-homed esi 11:22:33:44:55:66:77:88:99 load-
balancing single-active
OcNOS(config-if-es)#service-carving preference-based
OcNOS(config-if-es)#service-carving ac-driven
OcNOS(config-if-es)#end

OcNOS#configure terminal
OcNOS(config)#interface sa1
OcNOS(config-if)#evpn multi-homed esi 11:22:33:44:55:66:77:88:99 load-
balancing single-active
OcNOS(config-if-es)#service-carving auto
OcNOS(config-if-es)#service-carving ac-driven

OcNOS(config-if-es)#no service-carving ac-driven
OcNOS(config-if-es)#end
```

service-carving

Use this command to provide the flexibility to select the Designated Forwarder (DF) election algorithm based on preference based or modulo-based DF election.

Use no form of this command to disable service-carving.

Command Syntax

```
service-carving (preference-based|auto)
no service-carving
```

Parameters

preference-based	Select the DF election algorithm based on preference based.
auto	Select the DF election algorithm based on modulo based.

Default

None

Command Mode

EVPN ES Mode

Applicability

This command was introduced in the OcNOS version 6.4.1.

Example

The following examples demonstrate the configuration of the `service-carving` command in both `single-active` or `port-active` mode for the EVPN multi-homed system, with one utilizing `auto` service carving and the other using preference-based service carving.

```
OcNOS#configure terminal
OcNOS(config)#interface sal
OcNOS(config-if)#evpn multi-homed esi 11:22:33:44:55:66:77:88:99 load-
balancing single-active
OcNOS(config-if-es)#service-carving auto
OcNOS(config-if-es)#end
```

```
OcNOS#configure terminal
OcNOS(config)#interface pol
OcNOS(config-if)#evpn multi-homed system-mac 0000.0000.0011 load-balancing
port-active
OcNOS(config-if-es)#service-carving auto
OcNOS(config-if-es)#end
```

```
OcNOS#configure terminal
OcNOS(config)#interface pol
OcNOS(config-if)#evpn multi-homed system-mac 0000.0000.0011 load-balancing
port-active
OcNOS(config-if-es)#service-carving preference-based
OcNOS(config-if-es)#end
```

The following example is used to disable the `service-carving` for the EVPN multi-homed system.

```
OcNOS(config-if-es)#no service-carving
OcNOS(config-if-es)#end
```

service-carving weight

Use this command to specify a preference value when the preference-based Designated Forwarder (DF) election algorithm is selected. This preference value determines the priority of the local PE device to become the DF for a particular Ethernet segment.

Use no form of this command to replace the preference weight value and choose the default preference value.

Command Syntax

```
service-carving weight <1-65535>
no service-carving weight
```

Parameters

`weight <1-65535>` Specifies the preference weight value. A lower weight value indicates a higher priority for becoming the DF.

Default

The service-carving weight command is set to 32767 by default.

Command Mode

EVPN Ethernet Segment (ES) Mode

Applicability

This command was introduced in the OcNOS version 6.4.1.

Example

The `service-carving weight` command is used to configure the preference weight value for service-carving in both port-active and single-active modes.

```
OcNOS#configure terminal
OcNOS(config)#interface po1
OcNOS(config-if)#evpn multi-homed system-mac 0000.0000.0011 load-balancing
port-active
OcNOS(config-if-es)#service-carving preference-based
OcNOS(config-if-es)#service-carving weight 100
OcNOS(config-if-es)#end
```

```
OcNOS#configure terminal
OcNOS(config)#interface sa1
OcNOS(config-if)#evpn multi-homed esi 11:22:33:44:55:66:77:88:99 load-
balancing single-active
OcNOS(config-if-es)#service-carving preference-based
OcNOS(config-if-es)#service-carving weight 100
```

To disable the configured weight, use the `no service-carving weight` command.

```
OcNOS(config-if-es)#no service-carving weight
OcNOS(config-if-es)#end
```

Revised CLI Commands

Below is the revised command for configuring EVPN Active-Standby.

evpn multi-homed

- The command `evpn multi-homed` allows users to configure single-active and port-active load-balancing Ethernet Segment Identifier (ESI) on a link with a multihomed Customer Edge (CE) in the context of EVPN multi-homed configurations. For more details, refer to the [evpn multi-homed](#) command in the [EVPN MPLS Commands](#) chapter in the Multi-Protocol Label Switching Guide.
- The existing syntax now includes the newly added parameter for load-balancing, namely `single-active` and `port-active`.

Troubleshooting

To ensure the reliable operation of the single-active or port-active setup and maintain data accuracy and consistency, follow these troubleshooting steps:

1. Verify the Configuration:

- Use the `show running-config` command to confirm that the ESI configuration includes `load-balancing single-active` or `port-active`, such as:

```
evpn multi-homed esi 11:22:33:44:55:66:77:88:99 load-balancing single-active
```

or

```
evpn multi-homed system-mac 0000.4321.1234 load-balancing port-active
```
- Ensure that the `service-carving` algorithm type is configured.

2. Verify the `show` command:

- Use the `show bgp l2vpn evpn multihoming es-route` command to confirm that it matches the `service-carving` algorithm type.
- Use the `show evpn load-balance single-active` or `port-active` command to verify the status of the Multihomed (MH) nodes as `ACTIVE` and `STANDBY`.

3. Ensure Proper Connectivity: Validate the connectivity between the router and the EVPN tunnel to ensure it is up. This involves verifying network settings, ports, and firewalls.**4. For the server:** Enable debugging on OcNOS and enable debug mode. Verify the logs in `/var/log/messages` for further insights.

Abbreviations

The following are some key abbreviations and their meanings relevant to this document:

Acronym	Description
EVPN	Ethernet Virtual Private Network
ELINE	Ethernet Line services
ELAN	Ethernet LAN services
LAN	Local Area Network
CE	Customer Edge
PE	Provider Edge
MH	Multihoming
AC	Attachment Circuit
LACP	Link Aggregation Control Protocol
BUM	Broadcast, Unknown Unicast, Multicast
MAC	Media Access Control
ARP/ND	Address Resolution Protocol/Neighbor Discovery
DF	Designated Forwarder

Glossary

The following provides definitions for key terms used throughout this document.

Ethernet Virtual Private Network (EVPN)	A network technology that extends Layer 2 Ethernet services over a Layer 3 IP/MPLS network.
Ethernet Line services (ELINE)	Two PEs are directly connected over an Ethernet link, enabling redundancy and efficient data exchange.
Ethernet LAN services (ELAN)	A group of PEs are interconnected in a multipoint Ethernet network, providing redundancy and optimized data transfer.
Port-Active	A redundancy mechanism in which multiple Provider Edge (PE) devices can be active simultaneously for the same host or MAC address, with specific active ports associated with each active PE.
Single-Active	A redundancy mechanism in which only one of the Provider Edge (PE) devices is active at a time for handling traffic for a specific host or MAC address.
Customer Edge (CE)	A device at the customer's network edge that connects to the service provider's network.
Provider Edge (PE)	A device at the service provider's network edge that connects to customer edge devices.
Multihoming (MH)	Connecting a host or CE device to multiple PE devices for redundancy and load balancing.
Attachment Circuit (AC)	The connection between a CE device and a PE device in an EVPN network.
Link Aggregation Control Protocol (LACP)	A protocol used to manage and bundle multiple physical links into a single logical link for higher bandwidth and redundancy.
Broadcast, Unknown Unicast, Multicast (BUM)	Categories of network traffic that includes broadcast, unknown unicast, and multicast packets.
Media Access Control (MAC)	A unique identifier assigned to network interfaces, typically associated with a hardware address.
Address Resolution Protocol/Neighbor Discovery (ARP/ND)	Protocols used to map IP addresses to MAC addresses in a local network.
Designated Forwarder (DF)	A PE device selected to forward broadcast, unknown unicast, and multicast traffic within an Ethernet segment.
Redundancy	The provision of duplicate equipment or links to ensure network availability in case of failures.
Failover	The process of switching to a backup device or link in case of a primary device or link failure.
Resiliency	The ability of a network to maintain its functionality even in the face of failures or disruptions.
Unicast	Communication between a single sender and a single receiver in a network.
Multicast	Communication from a single sender to multiple receivers in a network.

Egress	The process of traffic leaving a device or network segment.
Standby	In redundancy, a secondary device or link that is ready to take over in case the primary device or link fails.
Active	In redundancy, the primary device or link that is currently handling traffic.
Forwarding	The process of transmitting network packets from one device to another.
Link State	The operational status of a network link, indicating whether it is up or down.
Virtual Routing and Forwarding (VRF)	A technology that enables multiple instances of a routing table to coexist within a router.
Virtual Local Area Network (VLAN)	A logical network segment within a physical network.
Data Exchange	The process of sending and receiving data between network devices.
Downtime	The period during which a network or service is not available due to maintenance or failures.

CHAPTER 4 EVPN MPLS E-Tree

Overview

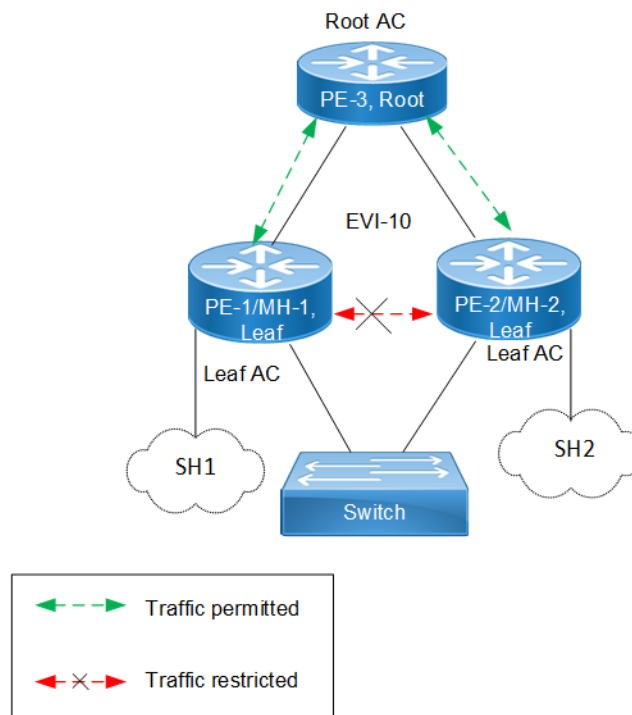
Ethernet VPN Ethernet-Tree (EVPN E-Tree), is a networking solution designed to manage communication within broadcast domains, incorporating redundancy through multi-homing in a network. It optimizes traffic routing and control, especially in scenarios where specific services or devices need controlled communication. It categorizes network nodes based on predefined definitions of EVPN Instances as Leaf or Root, allowing or restricting communication between them.

Feature Characteristics

Implemented Scenario 1 of the EVPN E-Tree solution, as defined by RFC-8317, designates each Provider Edge (PE) node as either a Leaf or a Root site per Virtual Private Network (VPN) for VXLAN and MPLS EVPN in OcNOS.

Scenario 1: Leaf or Root Site(s) per PE

Scenario 1 involves a topology with three PE nodes: PE-1, PE-2, and PE-3. PE-1 and PE-2 are Multi-Homed nodes (MH-1 and MH-2), with PE-3 acting as the Root node. PE-1 and PE-2 function as Leaf nodes and are part of a single home access interface (SH1 and SH2).



The classification ensures that communication follows specific rules:

- Communication between Leaf hosts is restricted, as indicated by red dotted lines with a cross mark (X) in the topology diagram. However, communication between Leaf and Root nodes, as well as between Root nodes, is permitted, marked by green dotted lines.

- Leaf nodes within PE-1 and PE-2 are isolated from each other, preventing intra-PE communication.

The scenario 1 is achieved through two main concepts:

1. Inter-PE Communication

- The inter-PE Route Target (RT) Constraint Method is applicable only to Single-Homing (SH) devices. Two RTs per broadcast domain are utilized, with Leaf PEs exporting Leaf RTs and Root nodes exporting Root RTs. Leaf nodes import only Root RTs, allowing communication with Root PEs while preventing communication with other Leaf nodes. RT constraints limit the import of specific EVPN routes (MAC-IP and IMET routes) to designated paths for inter-PE communication.
- IPI employs a proprietary method to support inter-PE connectivity for both SH and MH devices, using BGP extended community to advertise Leaf Indication in BGP routes and influence traffic flow for both Unicast and BUM traffic. This method enables implementation of ARP or ND cache suppression and MAC mobility sub-features specified in RFC-7432.

2. Intra-PE communication: Local Split Horizon controls intra-PE communication between Attachment Circuits (ACs) within Leaf PE nodes, ensuring that traffic between ACs does not egress to other Leaf ACs.

Note: This functionality depends on hardware capabilities.

Benefits

EVPN E-Tree offers benefits in networking environments by providing efficient traffic control, enhanced security, scalability, and improved performance.

Efficient Traffic Control: EVPN E-Tree allows for efficient control over traffic within network broadcast domains. By segregating nodes into Leaf and Root categories, it enables precise management of communication flows, ensuring the traffic is directed only where needed.

Enhanced Security: The isolation of Leaf hosts from each other adds a layer of security to the network. This prevents unauthorized communication between devices within the same broadcast domain, reducing the risk of data breaches and unauthorized access.

Scalability: EVPN E-Tree is scalable, making it suitable for networks of various sizes and complexities. Whether deploying in small-scale environments or large enterprise networks, EVPN E-Tree offers flexibility and scalability to meet evolving business needs.

Improved Performance: By controlling communication paths and optimizing traffic flows, EVPN E-Tree can improve network performance. This ensures that critical data packets are delivered efficiently, reducing latency and enhancing overall network performance.

Prerequisites

In setting up a MPLS EVPN network, certain prerequisites are essential to ensure proper functionality and connectivity.

Ensure MPLS EVPN Configuration: Confirm that MPLS EVPN and MPLS MH filtering are already enabled in all leaf and root nodes of the network as they are required for MPLS EVPN Multihoming.

```
!
hardware-profile filter evpn-mpls-mh enable
!
evpn mpls enable
!
evpn mpls multihoming enable
!
qos enable
```

```
!
```

Define Interfaces and Loopback Addresses: Configure Layer 2 interfaces, like port channel interfaces (e.g., po1), and assign specific system MAC addresses for proper identification and routing. Additionally, assign loopback IP addresses to establish essential points of connectivity. These configurations establish the efficient network routing and communication.

```
!
interface po1
  switchport
  load-interval 30
  evpn multi-homed system-mac 0000.4321.1234
!
interface lo
  ip address 8.8.8.8/32 secondary
  ip router isis ISIS-IGP
  enable-ldp ipv4
!
interface xe8
  switchport
!
interface xe26
  channel-group 1 mode active
!
```

Configure ISIS and BGP for Dynamic Routing: Enable ISIS to facilitate dynamic routing on all Leaf and Root nodes within the network. Define ISIS router instances to match loopback IP addresses and add network segments to ISIS areas for proper route distribution. Additionally, establish BGP sessions to advertise routes between different nodes. Set up neighbor relationships using loopback IP addresses, ensuring efficient route advertisement and convergence for optimal network performance.

```
!
router isis ISIS-IGP
  is-type level-1
  ignore-lsp-errors
  lsp-gen-interval 5
  spf-interval-exp level-1 50 2000
  metric-style wide
  mpls traffic-eng router-id 8.8.8.8
  mpls traffic-eng level-1
  capability cspf
  dynamic-hostname
  fast-reroute terminate-hold-on interval 10000
  fast-reroute per-prefix level-1 proto ipv4 all
  fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
  bfd all-interfaces
  net 49.0001.0000.0000.0008.00
!
router bgp 65535
  neighbor 9.9.9.9 remote-as 65535
  neighbor 24.24.24.24 remote-as 65535
  neighbor 26.26.26.26 remote-as 65535
  neighbor 29.29.29.29 remote-as 65535
  neighbor 9.9.9.9 update-source lo
  neighbor 9.9.9.9 fall-over bfd
  neighbor 24.24.24.24 update-source lo
  neighbor 24.24.24.24 fall-over bfd
  neighbor 26.26.26.26 update-source lo
  neighbor 26.26.26.26 fall-over bfd
```

```

neighbor 29.29.29.29 update-source lo
neighbor 29.29.29.29 fall-over bfd
!
address-family l2vpn evpn
neighbor 9.9.9.9 activate
neighbor 24.24.24.24 activate
neighbor 26.26.26.26 activate
neighbor 29.29.29.29 activate
exit-address-family
!
exit
!
```

Configure LDP and RSVP for Efficient Network Operation: Enable Label Distribution Protocol (LDP) and Resource Reservation Protocol (RSVP) on all Leaf and Root nodes to optimize traffic routing and quality of service. LDP assigns labels for packet forwarding, while RSVP reserves network resources along specified paths to enhance network performance and reliability.

```

!
router ldp
router-id 8.8.8.8
fast-reroute
graceful-restart full
graceful-restart timers neighbor-liveness 120
graceful-restart timers max-recovery 120
session-protection duration 10
targeted-peer ipv4 9.9.9.9
  exit-targeted-peer-mode
targeted-peer ipv4 24.24.24.24
  exit-targeted-peer-mode
transport-address ipv4 8.8.8.8
!
router rsvp
!
rsvp-path LEAF1-ROOT2 mpls
  24.1.4.24 strict
!
rsvp-path LEAF1-ROOT1 mpls
  26.1.2.26 strict
!
rsvp-trunk LEAF1-ROOT1 ipv4
  primary fast-reroute protection facility
  primary path LEAF1-ROOT1
  to 9.9.9.9
!
rsvp-trunk LEAF1-ROOT2 ipv4
  primary fast-reroute protection facility
  primary path LEAF1-ROOT2
  to 24.24.24.24
!
```

Create VRF for Isolated Routing Instances: Configure VRF on all Leaf and Root nodes to create isolated routing instances within the network. This enables separate routing tables and forwarding behaviors for different groups of network resources.

```

!
mac vrf vrf103
rd 8.8.8.8:103
route-target both 65535:103
```

!

Connect Network Interfaces: Configure network interfaces on all Leaf and Root nodes with connection details, IP addresses, and protocol settings. Enable label-switching and configure participation in the ISIS routing protocol, including support for protocols like LDP and RSVP for IPv4. These configurations optimize routing and resource management across the network.

```
!
interface xe11
  description connected to ROOT2 int xe9
  ip address 24.1.4.25/24
  label-switching
  ip router isis ISIS-IGP
  enable-ldp ipv4
  enable-rsvp
!
interface xe20
  description connected to ROOT1 int xe20
  ip address 26.1.2.27/24
  label-switching
  ip router isis ISIS-IGP
  enable-ldp ipv4
  enable-rsvp
!
```

Configure Switch: Set up a VLAN bridge by enabling the VLAN and associating specific VLANs with the bridge. Configure network interfaces as trunk ports to allow traffic for all permitted VLANs across the network. Designate interfaces connected to Leaf and Root nodes as member ports of the VLAN bridge. This setup optimizes network segmentation and traffic management

```
!
bridge 1 protocol rstp vlan-bridge
!
vlan database
  vlan-reservation 4030-4094
  vlan 2-3010 bridge 1 state enable
!
interface po100
  switchport
  bridge-group 1
  switchport mode trunk
  switchport trunk allowed vlan all
!
interface lo
  ip address 32.32.32.32/32 secondary
!
interface xe9
  channel-group 100 mode active
!
interface xe17
  channel-group 100 mode active
!
interface xe1
  switchport
  bridge-group 1
  switchport mode trunk
  switchport trunk allowed vlan all
!
exit
```

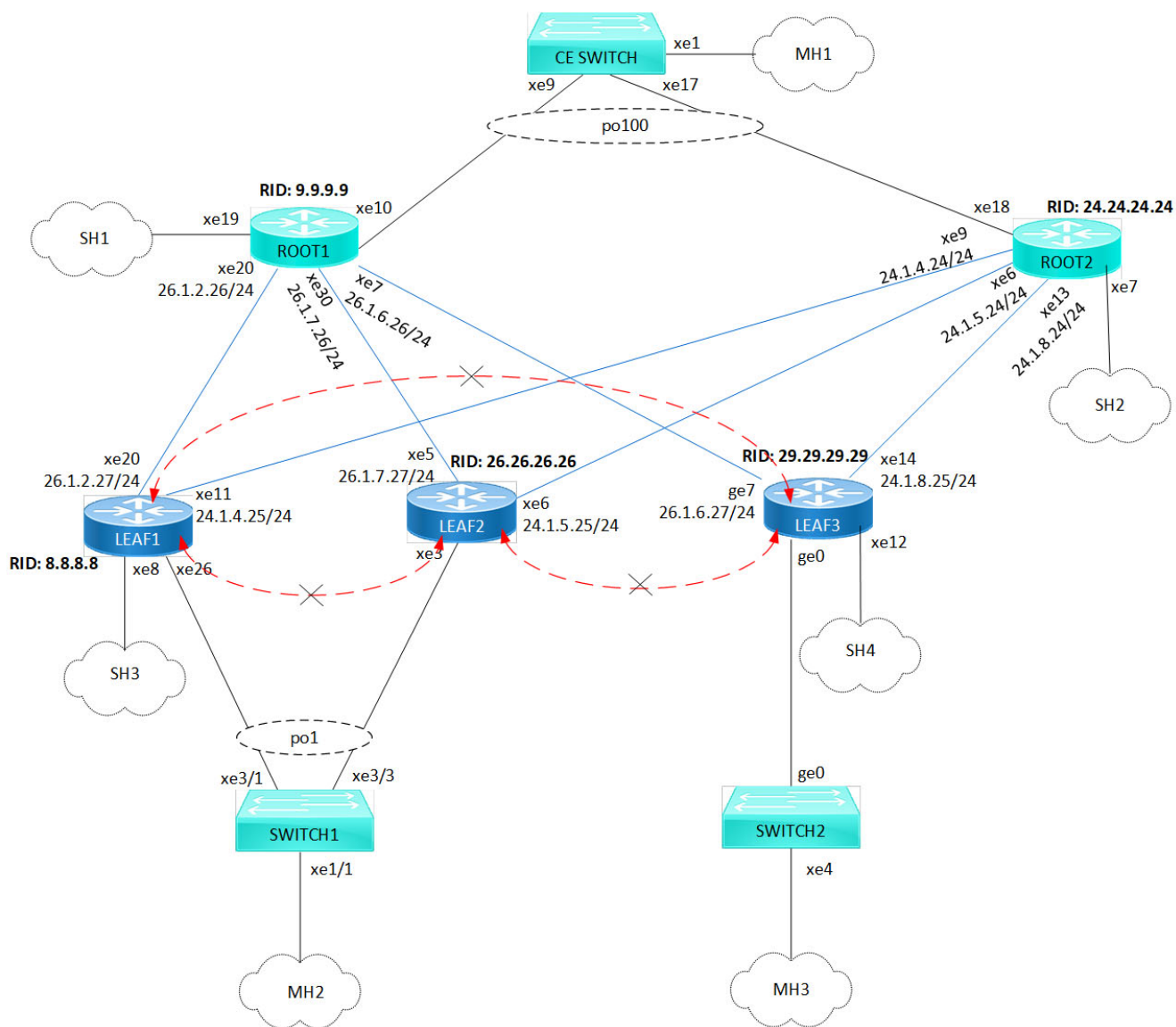
!

Configuration

Configure various nodes within the topology to set up an MPLS EVPN E-Tree network, ensuring EVPN E-Tree for All-Active and Active-Standby redundancy and load balancing.

Topology

In the sample topology, Leaf nodes (LEAF1, LEAF2, LEAF3, and LEAF4), Root nodes (ROOT1 and ROOT2), and Switches (CE SWITCH, SWITCH1, and SWITCH2) form the network architecture. LEAF1 and LEAF2 are part of a Multi-homed group, with both connected to `po1` (MH2). LEAF1 and LEAF3 have single home access-if ports (SH3 and SH4, respectively). Similarly, ROOT1 and ROOT2 are part of a Multi-homed group with `po100` (MH1), and they each have a single home access-if port (SH1 and SH2, respectively). Leaf nodes are interconnected, and CE SWITCH, SWITCH1, and SWITCH2 are configured for Multi-homed connections to Leaf and Root nodes. SWITCH1 connects to LEAF1 and LEAF2, while CE SWITCH links to ROOT1 and ROOT2.



BGP ID: 65535
ISIS Instance: ISIS-IGP
 Leaf nodes **VNID:203**
 EVPN MH System MAC
 • po1: 0000.4321.1234
 • po100: 0000.1111.2222
 ← × → Traffic between leaf nodes is restricted.

MPLS EVPN E-Tree Topology

Note: Before configuring E-Tree, meet all [Prerequisites](#) for the following nodes:

- Leaf nodes: LEAF1, LEAF2, and LEAF3
- Root nodes: ROOT1 and ROOT2
- Switches: CE SWITCH, SWITCH1 and SWITCH2

Enable EVPN E-Tree

The following E-Tree configurations applies to Leaf and Root nodes within the MPLS network.

1. Enable EVPN E-Tree which allows the nodes to participate in E-Tree functionality within the network, controlling traffic and establishing hierarchical connections between Leaf nodes in the network architecture.

```
(config)#evpn etree enable
```

2. Set the MAC ageing time (60 seconds) to allow MAC addresses learned over EVPN MPLS to remain in the MAC table before timing out. Configure the global VTEP IP address (8.8.8.8) which serves as the global identifier for MPLS encapsulation and decapsulation within the network, facilitating proper communication and tunnel establishment.

```
(config)#evpn mpls mac-ageing-time 60
(config)#evpn mpls vtep-ip-global 8.8.8.8
```

3. Define MPLS identifier (203) to support hierarchical connectivity and traffic control within the EVPN MPLS network. On the EVPN MPLS node, specify EVPN-BGP as the host reachability protocol for the specified VRF (vrf103) to communicate and exchange reachability information within the network. To enable EVPN E-Tree on Leaf nodes, configure etree-leaf along with the MPLS identifier. This allows for efficient replication of traffic at the ingress point, optimizing the functionality of E-Tree Leaf nodes within the network architecture.

```
(config)#evpn mpls id 203 etree-leaf
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf103
(config-evpn-mpls)#exit
```

4. Enable port-VLAN mapping (po1) with VLAN ID (103) to facilitate multi-homed access. Enable EVPN functionality on the interface, allowing it to participate in MAC address distribution across the network.

```
(config)#interface po1.103 switchport
(config-if)#encapsulation dot1q 103
(config-if)#load-interval 30
(config-access-if)#access-if-evpn
(config-access-if)#exit
```

Validation

Use the show commands described in this section to verify the network for proper MPLS EVPN E-Tree configuration.

Verify LDP sessions on all leaf and root nodes by using the `show ldp session` command. The `state` field (OPERATIONAL) indicates that the LDP session between the device and its peers is currently active.

```
LEAF1#show ldp session
```

```
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
Session has to be cleared manually
```

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	24.24.24.24	xe11	Passive	OPERATIONAL	30	01:13:29
	9.9.9.9	xe20	Passive	OPERATIONAL	30	01:13:29

Verify RSVP sessions on all leaf and root nodes by using the `show rsvp session` command. The `State` field (UP) indicates that the RSVP session between the ingress and egress routers is active and operational. Identify the different paths established within the network using the `LSPName` field.

```
LEAF1#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
```

```
Ingress RSVP:
To          From          Tun-ID  LSP-ID  Type  LSPName          State Uptime  Rt  Style  Labelin
Labelout
9.9.9.9     8.8.8.8     5001    2201    PRI   LEAF1-ROOT1-Primary  UP    01:13:16  1 1 SE    -      25601
24.24.24.24 8.8.8.8     5002    2202    PRI   LEAF1-ROOT2-Primary  UP    01:13:05  1 1 SE    -      25601
Total 2 displayed, Up 2, Down 0.
```

```
Egress RSVP:
To          From          Tun-ID  LSP-ID  Type  LSPName          State Uptime  Rt  Style  Labelin
Labelout
8.8.8.8     9.9.9.9     5001    2201    PRI   ROOT1-LEAF1-Primary  UP    01:13:45  1 1 SE    25600  -
8.8.8.8     24.24.24.24 5001    2201    PRI   ROOT2-LEAF1-Primary  UP    01:13:24  1 1 SE    25601  -
Total 2 displayed, Up 2, Down 0.
```

Verify the BGP session status on all leaf and root nodes, using the `show bgp l2vpn evpn summary` command output. The Up/Down field indicates the duration for which the BGP session has been up or down.

```
LEAF1#show bgp l2vpn evpn summary
BGP router identifier 8.8.8.8, local AS number 65535
BGP table version is 33
1 BGP AS-PATH entries
0 BGP community entries
```

Neighbor	V AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/PfxRcd	AD	MACIP	MCAST	ESI	PREFIX-ROUTE
9.9.9.9	4 65535	514	443	33	0	0	01:13:53	114	59	5	50	0	0
24.24.24.24	4 65535	504	443	33	0	0	01:13:54	109	59	0	50	0	0
26.26.26.26	4 65535	322	391	33	0	0	01:13:23	49	0	0	49	0	0
29.29.29.29	4 65535	197	392	33	0	0	01:13:54	6	0	0	6	0	0

Total number of neighbors 4

Total number of Established sessions 4

Verify ESI information and the forwarding tunnel status on all leaf and root nodes, by examining the `show evpn mpls` command output. The DF- Status field displays the forwarding status as either a Designated Forwarder (DF) or Non-Designated Forwarder (Non-DF), and the ESI field displays the Ethernet Segment Identifier associated with each entry.

```
LEAF1#show evpn mpls
EVPN-MPLS Information
=====
Codes: NW - Network Port
       AC - Access Port
       (u) - Untagged
```

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-Status	Src-Addr	Dst-Addr
203	----	L2	NW	----	----	----	----	8.8.8.8	29.29.29.29
203	----	L2	NW	----	----	----	----	8.8.8.8	9.9.9.9
203	----	L2	NW	----	----	----	----	8.8.8.8	24.24.24.24
203	----	L2	NW	----	----	----	----	8.8.8.8	26.26.26.26
203	----	--	AC	po1.103	00:00:00:43:21:12:34:00:00:00	----	DF	----	----
203	----	--	AC	po2.103	00:00:00:33:33:44:44:00:00:00	----	DF	----	----

Total number of entries are 252

Static MAC-IP Advertisement

Configure static MAC-IP advertisement through SH and MH from Root and Leaf nodes. Advertise static MAC addresses for both IPv4 and IPv6 from all MH and SH nodes. Ensure that nodes within the same MH have identical MAC addresses configured under the port-channel access port.

Configure MH Nodes

Configure static MAC addresses for IPv4 (30.30.30.3) and IPv6 (3000::1) under the MH access-port (po1) with VLAN ID (103). Repeat the same configurations for other MH nodes using different static MAC addresses for both IPv4 and IPv6.

```

!
interface po1.103 switchport
 access-if-evpn
  map vpn-id 203
  mac 0000.7777.9999
  mac 0000.7777.6666 ip 30.30.30.3
  mac 0000.7777.6666 ipv6 3001::1
!

```

Configure SH Nodes

Configure static MAC addresses for IPv4 (40.40.40.4) and IPv6 (4000::1) under the SH access-port (xe27) with VLAN ID (103). This setup ensures that SH advertises these static MAC addresses over the specified access-port. Repeat the same configurations for other SH nodes using different static MAC addresses for both IPv4 and IPv6.

```

!
interface xe27.103 switchport
 encapsulation dot1q 100
 load-interval 30
 access-if-evpn
  map vpn-id 203
  mac 0000.0000.0011
  mac 0000.5544.4455 ip 40.40.40.4
  mac 0000.5544.4455 ipv6 4000::1
!

```

Validation

Verify the MAC table entries on MH nodes (MH1, MH2 and MH3) and the SH nodes (SH1, SH2, SH3, and SH4). MH nodes advertise their MAC addresses using the ESI values. Additionally, verify the IP addresses associated with SH nodes for MAC advertisement.

In the `show evpn mpls mac-table` command output, the MAC entries originated from Leaf Nodes will have the `LeafFlag` field status set.

Note:

- MAC IPv4 or IPv6 configured under SH Leaf node access port will be advertised to the Root nodes and other Leaf nodes.
- MAC IPv4 or IPv6 configured under an MH Leaf node access port must be symmetric and will be advertised to both the Root nodes and other leaf nodes.
- MAC IPv4 or IPv6 configured under either SH or MH Root node will be advertised to both the Root nodes and the Leaf nodes.
- The Leaf-to-Leaf communication will display MAC status and tunnel status per VNI as Leaf type. The MAC will be in the discard state in the BCM shell.

```
LEAF1#show evpn mpls mac-table
```

```

=====
                        EVPN MPLS MAC Entries
=====
VNIID Interface  VlanId  In-VlanId  Mac-Addr      VTEP-IP/ESI      Type Status MAC move AccessPortDesc LeafFlag
-----
203  po1.103      ----    ----        0000.7777.9999 00:00:00:43:21:12:34:00:00:00 Static Local 0 ----- set
203  po1.103      ----    ----        0000.7777.6666 00:00:00:43:21:12:34:00:00:00 Static Local 0 ----- set

```

Total number of entries are : 8

```
ROOT1#show evpn mpls mac-table
```

```

=====
                        EVPN MPLS MAC Entries
=====

```



```

=====
VNID Interface VlanId In-VlanId Mac-Addr VTEP-Ip/ESI Type Status MAC move AccessPortDesc LeafFlag
=====
203 ---- ---- ---- 0000.7777.9999 00:00:00:43:21:12:34:00:00:00 Static Remote ----- 0 ----- set
203 ---- ---- ---- 0000.7777.6666 00:00:00:43:21:12:34:00:00:00 Static Remote ----- 0 ----- set

```

Total number of entries are : 8

Use the `show evpn mpls arp-cache` command to verify the Address Resolution Protocol (ARP) cache information on all nodes. This command displays entries that map IPv4 addresses to MAC addresses within the specified EVPN ID network.

```

LEAF1#show evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
=====

```

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
203	30.30.30.3	0000.7777.6666	Static Local	----	

Total number of entries are 5

```

ROOT1#show evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
=====

```

ARP Timeout : 570 sec Random-Jitter-Max : 200

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
203	30.30.30.3	0000.7777.6666	Static Remote	----	

Total number of entries are 5

Use the `show evpn mpls nd-cache` command to verify the Neighbor Discovery (ND) cache information on all nodes. This command displays entries that map IPv6 addresses to MAC addresses within the specified EVPN ID network.

```

LEAF1#show evpn mpls nd-cache
MPLS-EVPN ND-CACHE Information
=====

```

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
203	3001::1	0000.7777.6666	Static Local	----	

Total number of entries are 4

```

ROOT1#show evpn mpls nd-cache
MPLS-EVPN ND-CACHE Information
=====

```

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
203	3001::1	0000.7777.6666	Static Remote	----	

Total number of entries are 4

Network Topology Snippet Configurations

Here are the snippet configurations for all nodes in the given network topology.

LEAF1

```
!  
hardware-profile filter evpn-mpls-mh enable  
!  
evpn mpls enable  
!  
evpn esi hold-time 90  
!  
evpn etree enable  
!  
evpn mpls multihoming enable  
!  
mac vrf vrf103  
  rd 8.8.8.8:103  
  route-target both 65535:103  
!  
evpn mpls vtep-ip-global 8.8.8.8  
!  
evpn mpls mac-ageing-time 60  
!  
evpn mpls id 203 etree-leaf  
  host-reachability-protocol evpn-bgp vrf103  
!  
qos enable  
!  
router ldp  
  router-id 8.8.8.8  
  fast-reroute  
  graceful-restart full  
  graceful-restart timers neighbor-liveness 120  
  graceful-restart timers max-recovery 120  
  session-protection duration 10  
  targeted-peer ipv4 9.9.9.9  
    exit-targeted-peer-mode  
  targeted-peer ipv4 24.24.24.24  
    exit-targeted-peer-mode  
  transport-address ipv4 8.8.8.8  
!  
router rsvp  
!  
interface pol  
  switchport  
  load-interval 30  
  evpn multi-homed system-mac 0000.4321.1234  
!  
interface pol.103 switchport  
  encapsulation dot1q 103  
  load-interval 30  
  access-if-evpn  
    map vpn-id 203  
    mac 0000.7777.9999  
    mac 0000.7777.6666 ip 30.30.30.3  
    mac 0000.7777.6666 ipv6 3001::1  
!  
interface lo  
  ip address 8.8.8.8/32 secondary
```

```
ip router isis ISIS-IGP
enable-ldp ipv4
!
interface xe8
switchport
!
interface xe11
description connected to ROOT2 int xe9
ip address 24.1.4.25/24
label-switching
ip router isis ISIS-IGP
enable-ldp ipv4
enable-rsvp
!
interface xe20
description connected to ROOT1 int xe20
ip address 26.1.2.27/24
label-switching
ip router isis ISIS-IGP
enable-ldp ipv4
enable-rsvp
!
interface xe26
channel-group 1 mode active
!
interface xe27
speed 10g
!
interface xe27.100 switchport
encapsulation dot1q 100
load-interval 30
access-if-evpn
map vpn-id 200
mac 0000.0000.0011
mac 0000.5544.4455 ip 40.40.40.4
mac 0000.5544.4455 ipv6 4000::1
!
exit
!
router isis ISIS-IGP
is-type level-1
ignore-lsp-errors
lsp-gen-interval 5
spf-interval-exp level-1 50 2000
metric-style wide
mpls traffic-eng router-id 8.8.8.8
mpls traffic-eng level-1
capability cspf
dynamic-hostname
fast-reroute terminate-hold-on interval 10000
fast-reroute per-prefix level-1 proto ipv4 all
fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
bfd all-interfaces
net 49.0001.0000.0000.0008.00
!
router bgp 65535
neighbor 9.9.9.9 remote-as 65535
```

```

neighbor 24.24.24.24 remote-as 65535
neighbor 26.26.26.26 remote-as 65535
neighbor 29.29.29.29 remote-as 65535
neighbor 9.9.9.9 update-source lo
neighbor 9.9.9.9 fall-over bfd
neighbor 24.24.24.24 update-source lo
neighbor 24.24.24.24 fall-over bfd
neighbor 26.26.26.26 update-source lo
neighbor 26.26.26.26 fall-over bfd
neighbor 29.29.29.29 update-source lo
neighbor 29.29.29.29 fall-over bfd
!
address-family l2vpn evpn
neighbor 9.9.9.9 activate
neighbor 24.24.24.24 activate
neighbor 26.26.26.26 activate
neighbor 29.29.29.29 activate
exit-address-family
!
exit
!
rsvp-path LEAF1-ROOT2 mpls
 24.1.4.24 strict
!
rsvp-path LEAF1-ROOT1 mpls
 26.1.2.26 strict
!
rsvp-trunk LEAF1-ROOT1 ipv4
primary fast-reroute protection facility
primary path LEAF1-ROOT1
to 9.9.9.9
!
rsvp-trunk LEAF1-ROOT2 ipv4
primary fast-reroute protection facility
primary path LEAF1-ROOT2
to 24.24.24.24
!

```

LEAF2

```

!
hardware-profile filter evpn-mpls-mh enable
!
evpn mpls enable
!
evpn esi hold-time 90
!
evpn mpls multihoming enable
!
mac vrf vrf103
rd 26.26.26.26:103
route-target both 65535:103
!
evpn mpls vtep-ip-global 26.26.26.26
!
evpn mpls mac-ageing-time 60

```

```
!  
evpn mpls id 203 etree-leaf  
  host-reachability-protocol evpn-bgp vrf103  
!  
qos enable  
!  
router ldp  
  router-id 26.26.26.26  
  fast-reroute  
  graceful-restart full  
  graceful-restart timers neighbor-liveness 120  
  graceful-restart timers max-recovery 120  
  session-protection duration 10  
  targeted-peer ipv4 9.9.9.9  
    exit-targeted-peer-mode  
  targeted-peer ipv4 24.24.24.24  
    exit-targeted-peer-mode  
  transport-address ipv4 26.26.26.26  
!  
router rsvp  
!  
interface pol  
  switchport  
  load-interval 30  
  evpn multi-homed system-mac 0000.4321.1234  
!  
interface pol.103 switchport  
  encapsulation dot1q 103  
  load-interval 30  
  access-if-evpn  
  map vpn-id 203  
!  
interface lo  
  ip address 26.26.26.26/32 secondary  
  ip router isis ISIS-IGP  
  enable-ldp ipv4  
!  
interface xe3  
  channel-group 1 mode active  
!  
interface xe5  
  description connected to ROOT1 int xe30  
  ip address 26.1.7.27/24  
  label-switching  
  ip router isis ISIS-IGP  
  enable-ldp ipv4  
  enable-rsvp  
!  
interface xe6  
  description connected to ROOT2 int xe6  
  ip address 24.1.5.25/24  
  label-switching  
  ip router isis ISIS-IGP  
  enable-ldp ipv4  
  enable-rsvp  
!  
exit
```

```

!
router isis ISIS-IGP
 is-type level-1
 ignore-lsp-errors
 lsp-gen-interval 5
 spf-interval-exp level-1 50 2000
 metric-style wide
 mpls traffic-eng router-id 26.26.26.26
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 fast-reroute terminate-hold-on interval 10000
 fast-reroute per-prefix level-1 proto ipv4 all
 fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
 bfd all-interfaces
 net 49.0001.0000.0000.0026.00
!
router bgp 65535
 neighbor 8.8.8.8 remote-as 65535
 neighbor 9.9.9.9 remote-as 65535
 neighbor 24.24.24.24 remote-as 65535
 neighbor 29.29.29.29 remote-as 65535
 neighbor 8.8.8.8 update-source lo
 neighbor 8.8.8.8 fall-over bfd
 neighbor 9.9.9.9 update-source lo
 neighbor 9.9.9.9 fall-over bfd
 neighbor 24.24.24.24 update-source lo
 neighbor 24.24.24.24 fall-over bfd
 neighbor 29.29.29.29 update-source lo
 neighbor 29.29.29.29 fall-over bfd
!
 address-family l2vpn evpn
  neighbor 8.8.8.8 activate
  neighbor 9.9.9.9 activate
  neighbor 24.24.24.24 activate
  neighbor 29.29.29.29 activate
 exit-address-family
!
 exit
!
rsvp-path LEAF2-ROOT2 mpls
 24.1.5.24 strict
!
rsvp-path LEAF2-ROOT1 mpls
 26.1.7.26 strict
!
rsvp-trunk LEAF2-ROOT1 ipv4
 primary fast-reroute protection facility
 primary path LEAF2-ROOT1
 to 9.9.9.9
!
rsvp-trunk LEAF2-ROOT2 ipv4
 primary fast-reroute protection facility
 primary path LEAF2-ROOT2
 to 24.24.24.24
!

```

LEAF3

```
!  
evpn mpls enable  
!  
mac vrf vrf103  
  rd 29.29.29.29:103  
  route-target both 65535:103  
!  
evpn mpls vtep-ip-global 29.29.29.29  
!  
evpn mpls mac-ageing-time 60  
!  
evpn mpls id 203 etree-leaf  
  host-reachability-protocol evpn-bgp vrf103  
!  
qos enable  
!  
router ldp  
  router-id 29.29.29.29  
  fast-reroute  
  graceful-restart full  
  graceful-restart timers neighbor-liveness 120  
  graceful-restart timers max-recovery 120  
  session-protection duration 10  
  targeted-peer ipv4 9.9.9.9  
    exit-targeted-peer-mode  
  targeted-peer ipv4 24.24.24.24  
    exit-targeted-peer-mode  
  transport-address ipv4 29.29.29.29  
!  
router rsvp  
!  
interface ge0  
  static-channel-group 3  
!  
interface ge7  
  description connected to ROOT1 int xe7  
  ip address 26.1.6.27/24  
  label-switching  
  ip router isis ISIS-IGP  
  enable-ldp ipv4  
  enable-rsvp  
!  
interface lo  
  ip address 29.29.29.29/32 secondary  
  ip router isis ISIS-IGP  
  enable-ldp ipv4  
!  
interface xel2  
  switchport  
!  
interface xel2.103 switchport  
  encapsulation dot1q 103  
  load-interval 30  
  access-if-evpn  
  map vpn-id 203
```

```
!  
interface xe14  
  description connected to ROOT2 int xe13  
  ip address 24.1.8.25/24  
  label-switching  
  ip router isis ISIS-IGP  
  enable-ldp ipv4  
  enable-rsvp  
!  
  exit  
!  
router isis ISIS-IGP  
  is-type level-1  
  ignore-lsp-errors  
  lsp-gen-interval 5  
  spf-interval-exp level-1 50 2000  
  metric-style wide  
  mpls traffic-eng router-id 29.29.29.29  
  mpls traffic-eng level-1  
  capability cspf  
  dynamic-hostname  
  fast-reroute terminate-hold-on interval 10000  
  fast-reroute per-prefix level-1 proto ipv4 all  
  fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp  
  bfd all-interfaces  
  net 49.0001.0000.0000.0029.00  
!  
router bgp 65535  
  neighbor 8.8.8.8 remote-as 65535  
  neighbor 9.9.9.9 remote-as 65535  
  neighbor 24.24.24.24 remote-as 65535  
  neighbor 26.26.26.26 remote-as 65535  
  neighbor 8.8.8.8 update-source lo  
  neighbor 8.8.8.8 fall-over bfd  
  neighbor 9.9.9.9 update-source lo  
  neighbor 9.9.9.9 fall-over bfd  
  neighbor 24.24.24.24 update-source lo  
  neighbor 24.24.24.24 fall-over bfd  
  neighbor 26.26.26.26 update-source lo  
  neighbor 26.26.26.26 fall-over bfd  
!  
  address-family l2vpn evpn  
  neighbor 8.8.8.8 activate  
  neighbor 9.9.9.9 activate  
  neighbor 24.24.24.24 activate  
  neighbor 26.26.26.26 activate  
  exit-address-family  
!  
  exit  
!  
  rsvp-path LEAF3-ROOT2 mpls  
    24.1.8.24 strict  
!  
  rsvp-path LEAF3-ROOT1 mpls  
    26.1.6.26 strict  
!  
  rsvp-trunk LEAF3-ROOT1 ipv4
```



```
primary fast-reroute protection facility
primary path LEAF3-ROOT1
to 9.9.9.9
!
rsvp-trunk LEAF3-ROOT2 ipv4
primary fast-reroute protection facility
primary path LEAF3-ROOT2
to 24.24.24.24
!
```

ROOT1

```
!
hardware-profile filter evpn-mpls-mh enable
!
evpn mpls enable
!
evpn esi hold-time 90
!
evpn mpls multihoming enable
!
mac vrf vrf103
rd 9.9.9.9:103
route-target both 65535:103
!
evpn mpls vtep-ip-global 9.9.9.9
!
evpn mpls mac-ageing-time 60
!
evpn mpls id 203
host-reachability-protocol evpn-bgp vrf103
!
qos enable
!
bridge 1 protocol rstp vlan-bridge
!
router ldp
router-id 9.9.9.9
fast-reroute
graceful-restart full
graceful-restart timers neighbor-liveness 120
graceful-restart timers max-recovery 120
session-protection duration 10
targeted-peer ipv4 8.8.8.8
exit-targeted-peer-mode
targeted-peer ipv4 26.26.26.26
exit-targeted-peer-mode
transport-address ipv4 9.9.9.9
!
router rsvp
!
interface po100
switchport
load-interval 30
evpn multi-homed system-mac 0000.1111.2222
!
interface po100.103 switchport
```

```
encapsulation dot1q 103
load-interval 30
access-if-evpn
  map vpn-id 203
!
interface lo
ip address 9.9.9.9/32 secondary
ip router isis ISIS-IGP
enable-ldp ipv4
!
interface xe7
description connected to LEAF3 int ge7
speed 1g
ip address 26.1.6.26/24
label-switching
ip router isis ISIS-IGP
enable-ldp ipv4
enable-rsvp
!
interface xe10
channel-group 100 mode active
!
interface xe17.100 switchport
description for Static mac advertize
encapsulation dot1q 100
load-interval 30
access-if-evpn
  map vpn-id 200
  mac 0000.0000.0022
  mac 0000.00dc.0001 ip 10.10.10.1
  mac 0000.00dc.0001 ipv6 1001::1
!
interface xe19
switchport
!
interface xe20
description connected to LEAF1 int xe20
ip address 26.1.2.26/24
label-switching
ip router isis ISIS-IGP
enable-ldp ipv4
enable-rsvp
!
interface xe30
description connected to LEAF2 int xe5
speed 10g
ip address 26.1.7.26/24
label-switching
ip router isis ISIS-IGP
enable-ldp ipv4
enable-rsvp
!
exit
!
router isis ISIS-IGP
is-type level-1
ignore-lsp-errors
```

```

lsp-gen-interval 5
spf-interval-exp level-1 50 2000
metric-style wide
mpls traffic-eng router-id 9.9.9.9
mpls traffic-eng level-1
capability cspf
dynamic-hostname
fast-reroute terminate-hold-on interval 10000
fast-reroute per-prefix level-1 proto ipv4 all
fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
bfd all-interfaces
net 49.0001.0000.0000.0009.00
!
router bgp 65535
neighbor 8.8.8.8 remote-as 65535
neighbor 24.24.24.24 remote-as 65535
neighbor 26.26.26.26 remote-as 65535
neighbor 29.29.29.29 remote-as 65535
neighbor 8.8.8.8 update-source lo
neighbor 8.8.8.8 fall-over bfd
neighbor 24.24.24.24 update-source lo
neighbor 24.24.24.24 fall-over bfd
neighbor 26.26.26.26 update-source lo
neighbor 26.26.26.26 fall-over bfd
neighbor 29.29.29.29 update-source lo
neighbor 29.29.29.29 fall-over bfd
!
address-family l2vpn evpn
neighbor 8.8.8.8 activate
neighbor 24.24.24.24 activate
neighbor 26.26.26.26 activate
neighbor 29.29.29.29 activate
exit-address-family
!
exit
!
rsvp-path ROOT1-LEAF3 mpls
26.1.6.27 strict
!
rsvp-path ROOT1-LEAF2 mpls
26.1.7.27 strict
!
rsvp-path ROOT1-LEAF1 mpls
26.1.2.27 strict
!
rsvp-trunk ROOT1-LEAF1 ipv4
primary fast-reroute protection facility
primary path ROOT1-LEAF1
to 8.8.8.8
!
rsvp-trunk ROOT1-LEAF2 ipv4
primary fast-reroute protection facility
primary path ROOT1-LEAF2
to 26.26.26.26
!
rsvp-trunk ROOT1-LEAF3 ipv4
primary fast-reroute protection facility

```

```

primary path ROOT1-LEAF3
to 29.29.29.29
!

```

ROOT2

```

!
hardware-profile filter evpn-mpls-mh enable
!
evpn mpls enable
!
evpn esi hold-time 90
!
evpn mpls multihoming enable
!
mac vrf vrf103
  rd 24.24.24.24:103
  route-target both 65535:103
!
evpn mpls vtep-ip-global 24.24.24.24
!
evpn mpls mac-ageing-time 60
!
evpn mpls id 203
  host-reachability-protocol evpn-bgp vrf103
!
qos enable
!
router ldp
  router-id 24.24.24.24
  fast-reroute
  graceful-restart full
  graceful-restart timers neighbor-liveness 120
  graceful-restart timers max-recovery 120
  session-protection duration 10
  targeted-peer ipv4 8.8.8.8
    exit-targeted-peer-mode
  targeted-peer ipv4 26.26.26.26
    exit-targeted-peer-mode
  transport-address ipv4 24.24.24.24
!
router rsvp
!
interface po100
  switchport
  load-interval 30
  evpn multi-homed system-mac 0000.1111.2222
!
interface po100.103 switchport
  encapsulation dot1q 103
  load-interval 30
  access-if-evpn
  map vpn-id 203
!
interface lo
  ip address 24.24.24.24/32 secondary
  ip router isis ISIS-IGP

```

```
enable-ldp ipv4
!
interface xe6
description connected to LEAF2 int xe6
speed 10g
ip address 24.1.5.24/24
label-switching
ip router isis ISIS-IGP
enable-ldp ipv4
enable-rsvp
!
interface xe7
switchport
!
interface xe9
description connected to LEAF1 int xe11
speed 10g
ip address 24.1.4.24/24
label-switching
ip router isis ISIS-IGP
enable-ldp ipv4
enable-rsvp
!
interface xe13
description connected to LEAF3 int xe14
speed 10g
ip address 24.1.8.24/24
label-switching
ip router isis ISIS-IGP
enable-ldp ipv4
enable-rsvp
!
interface xe18
channel-group 100 mode active
!
exit
!
router isis ISIS-IGP
is-type level-1
ignore-lsp-errors
lsp-gen-interval 5
spf-interval-exp level-1 50 2000
metric-style wide
mpls traffic-eng router-id 24.24.24.24
mpls traffic-eng level-1
capability cspf
dynamic-hostname
fast-reroute terminate-hold-on interval 10000
fast-reroute per-prefix level-1 proto ipv4 all
fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
bfd all-interfaces
net 49.0001.0000.0000.0024.00
!
router bgp 65535
neighbor 8.8.8.8 remote-as 65535
neighbor 9.9.9.9 remote-as 65535
neighbor 26.26.26.26 remote-as 65535
```

```

neighbor 29.29.29.29 remote-as 65535
neighbor 8.8.8.8 update-source lo
neighbor 8.8.8.8 fall-over bfd
neighbor 9.9.9.9 update-source lo
neighbor 9.9.9.9 fall-over bfd
neighbor 26.26.26.26 update-source lo
neighbor 26.26.26.26 fall-over bfd
neighbor 29.29.29.29 update-source lo
neighbor 29.29.29.29 fall-over bfd
!
address-family l2vpn evpn
neighbor 8.8.8.8 activate
neighbor 9.9.9.9 activate
neighbor 26.26.26.26 activate
neighbor 29.29.29.29 activate
exit-address-family
!
exit
!
rsvp-path ROOT2-LEAF1 mpls
  24.1.4.25 strict
!
rsvp-path ROOT2-LEAF2 mpls
  24.1.5.25 strict
!
rsvp-path ROOT2-LEAF3 mpls
  24.1.8.25 strict
!
rsvp-trunk ROOT2-LEAF1 ipv4
  primary fast-reroute protection facility
  primary path ROOT2-LEAF1
  to 8.8.8.8
!
rsvp-trunk ROOT2-LEAF2 ipv4
  primary fast-reroute protection facility
  primary path ROOT2-LEAF2
  to 26.26.26.26
!
rsvp-trunk ROOT2-LEAF3 ipv4
  primary fast-reroute protection facility
  primary path ROOT2-LEAF3
  to 29.29.29.29
!

```

CE SWITCH

```

!
bridge 1 protocol rstp vlan-bridge
!
vlan database
  vlan-reservation 4030-4094
  vlan 2-3010 bridge 1 state enable
!
interface po100
  switchport
  bridge-group 1
  switchport mode trunk

```

```

    switchport trunk allowed vlan all
    !
interface lo
    ip address 32.32.32.32/32 secondary
    !
interface xe9
    channel-group 100 mode active
    !
interface xe17
    channel-group 100 mode active
    !
interface xe1
    switchport
    bridge-group 1
    switchport mode trunk
    switchport trunk allowed vlan all
    !
    exit
    !

```

SWITCH1

```

    !
bridge 1 protocol rstp vlan-bridge
    !
    vlan-reservation 4020-4062
    vlan 2-3000 bridge 1 state enable
    !
interface po1
    switchport
    bridge-group 1
    switchport mode trunk
    switchport trunk allowed vlan all
    !
interface lo
    ip address 7.7.7.7/32 secondary
    !
interface xe1/1
    switchport
    bridge-group 1
    switchport mode trunk
    switchport trunk allowed vlan all
    !
interface xe3/1
    channel-group 1 mode active
    !
interface xe3/3
    channel-group 1 mode active
    !
    exit
    !

```

SWITCH2

```

    !
bridge 1 protocol rstp vlan-bridge
    !

```

```

vlan database
  vlan 2-3000 bridge 1 state enable
!
interface sa3
  switchport
  bridge-group 1
  switchport mode trunk
  switchport trunk allowed vlan all
!
interface ge0
  static-channel-group 3
!
interface lo
  ip address 23.23.23.23/32 secondary
!
interface xe4
  switchport
  bridge-group 1
  switchport mode trunk
  switchport trunk allowed vlan all
!

```

E-Tree Active-Standby Configuration

To set up an E-Tree network with Active-Standby redundancy and load balancing, follow these steps:

- Connect the Switch (P1) to the Root1, LEAF1, and LEAF2 nodes in the [MPLS EVPN E-Tree Topology](#).
- Set up the VRF, EVPN, Port-Active, and Single-Active Redundancy configuration on Root MH and Leaf MH nodes.

For more details on Active-Standby configuration, refer to the section [EVPN Active-Standby](#).

LEAF1

```

!
mac vrf vrf600
  rd 26.26.26.26:600
  route-target both 65535:600
!
evpn mpls id 681 etree-leaf
  host-reachability-protocol evpn-bgp vrf600
!
interface pol
  switchport
  load-interval 30
  evpn multi-homed system-mac 0000.4321.1234 load-balancing port-active
  service-carving auto
!
interface pol.681 switchport
  encapsulation dot1q 681
  load-interval 30
  access-if-evpn
  map vpn-id 681
!
interface sal
  switchport
  load-interval 30
  evpn multi-homed esi 11:22:33:00:00:00:55:66:77 load-balancing single-active

```



```

    service-carving auto
!
interface sa1.681 switchport
    encapsulation dot1q 681
    load-interval 30
    access-if-evpn
    map vpn-id 681
!
interface xe4
    description connected to P1 int xe43
    speed 10g
    load-interval 30
    ip address 25.1.2.25/24
    label-switching
    ip router isis ISIS-IGP
    enable-ldp ipv4
    enable-rsvp
!

```

LEAF2

```

!
mac vrf vrf600
    rd 26.26.26.26:600
    route-target both 65535:600
!
evpn mpls id 681 etree-leaf
    host-reachability-protocol evpn-bgp vrf600
!
interface pol
    switchport
    load-interval 30
    evpn multi-homed system-mac 0000.4321.1234 load-balancing port-active
    service-carving auto
!
interface pol.681 switchport
    encapsulation dot1q 681
    load-interval 30
    access-if-evpn
    map vpn-id 681
!
interface sa2
    switchport
    load-interval 30
    evpn multi-homed esi 11:22:33:00:00:00:55:66:77 load-balancing single-active
    service-carving auto
!
interface sa2.681 switchport
    encapsulation dot1q 681
    load-interval 30
    access-if-evpn
    map vpn-id 681
!
interface xe21
    description connected to P1 int xe43
    speed 10g
    load-interval 30

```

```
ip address 27.1.2.25/24
label-switching
ip router isis ISIS-IGP
enable-ldp ipv4
enable-rsvp
!
```

P1

```
!
router ldp
router-id 6.6.6.6
graceful-restart full
graceful-restart timers neighbor-liveness 120
graceful-restart timers max-recovery 120
session-protection duration 10
transport-address ipv4 6.6.6.6
!
interface lo
ip address 127.0.0.1/8
ip address 6.6.6.6/32 secondary
ipv6 address ::1/128
ip router isis ISIS-IGP
enable-ldp ipv4
!
interface xe43
description connected to LEAF1 int xe4
speed 10g
load-interval 30
ip address 25.1.2.24/24
label-switching
ip router isis ISIS-IGP
enable-ldp ipv4
enable-rsvp
!
interface xe45
description connected to ROOT1 int xe2
speed 10g
load-interval 30
ip address 26.1.3.27/24
label-switching
ip router isis ISIS-IGP
enable-ldp ipv4
enable-rsvp
!
interface xe47
description connected to LEAF2 int xe21
speed 10g
load-interval 30
ip address 27.1.2.24/24
label-switching
ip router isis ISIS-IGP
enable-ldp ipv4
enable-rsvp
!
exit
```

```

!
router isis ISIS-IGP
 is-type level-1
 authentication mode md5 level-1
 ignore-lsp-errors
 lsp-gen-interval 5
 spf-interval-exp level-1 50 2000
 metric-style wide
 mpls traffic-eng router-id 6.6.6.6
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 fast-reroute terminate-hold-on interval 10000
 fast-reroute per-prefix level-1 proto ipv4 all
 fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
 bfd all-interfaces
 net 49.0001.0000.0000.0006.00
!

```

Validation

To verify the status of the ESI, whether it's active or standby, use the `show evpn load-balance all` command. This command helps debug and understand if the election process is occurring correctly. For the ESI 00:00:00:43:21:12:34:00:00:00, LEAF1 is active, and LEAF2 is on standby in port-active mode. For the ESI 00:11:22:33:00:00:00:55:66:77, LEAF2 is active, and LEAF1 is on standby in single-active mode.

```

LEAF1#show evpn load-balance all

```

ESI	AC-IF/PE	PE-IP-ADDRESS	Redundancy	Service-carving	weight	Revertive	AC-DF	Status
00:00:00:43:21:12:34:00:00:00	LOCAL	8.8.8.8	port-active	auto	0	NO	NA	ACTIVE
00:00:00:43:21:12:34:00:00:00	REMOTE	26.26.26.26	port-active	auto	0	NO	NA	STANDBY
00:11:22:33:00:00:00:55:66:77	sa1.681	8.8.8.8	single-active	auto	0	NO	NO	STANDBY

```

LEAF2#show evpn load-balance all

```

ESI	AC-IF/PE	PE-IP-ADDRESS	Redundancy	Service-carving	weight	Revertive	AC-DF	Status
00:00:00:43:21:12:34:00:00:00	REMOTE	8.8.8.8	port-active	auto	0	NO	NA	ACTIVE
00:00:00:43:21:12:34:00:00:00	LOCAL	26.26.26.26	port-active	auto	0	NO	NA	STANDBY
00:11:22:33:00:00:00:55:66:77	sa2.681	26.26.26.26	single-active	auto	0	NO	NO	ACTIVE

All MAC addresses in Root and Leaf nodes will be synchronized.

```

LEAF1#show evpn mpls mac-table

```

EVPN MPLS MAC Entries								
VNID	Interface	VlanId	In-VlanId	Mac-Addr	VTEP-IP/ESI	Type	Status	
MAC move	AccessPortDesc	LeafFlag						
681	pol.681	----	----	0000.da00.0001	00:00:00:43:21:12:34:00:00:00	Dynamic Local	-----	
-	0	-----	set					
681	----	----	----	0000.ea00.0001	00:00:00:11:11:22:22:00:00:00	Dynamic Remote	-----	
-	0	-----	----					

Total number of entries are : 2

```

LEAF2#show evpn mpls mac-table

```

EVPN MPLS MAC Entries								
VNID	Interface	VlanId	In-VlanId	Mac-Addr	VTEP-IP/ESI	Type	Status	
MAC move	AccessPortDesc	LeafFlag						

```

681      ----      ----      ----      0000.da00.0001 00:00:00:43:21:12:34:00:00:00      Dynamic Remote      -----
-      0      ----      ----      set
681      ----      ----      ----      0000.ea00.0001 00:00:00:11:11:22:22:00:00:00      Dynamic Remote      -----
-      0      ----      ----      ----

```

Total number of entries are : 2

ROOT1#show evpn mpls mac-table

```

=====
                        EVPN MPLS MAC Entries
=====
VNID      Interface VlanId  In-VlanId Mac-Addr      VTEP-Ip/ESI      Type      Status
MAC move AccessPortDesc LeafFlag
-----
681      ----      ----      ----      0000.da00.0001 00:00:00:43:21:12:34:00:00:00      Dynamic Remote      -----
-      0      ----      ----      set
681      pol00.681 ----      ----      0000.ea00.0001 00:00:00:11:11:22:22:00:00:00      Dynamic Local      -----
-      0      ----      ----      ----

```

Total number of entries are : 2

Implementation Examples

Here is an example scenario and a solution for implementing EVPN E-Tree.

Scenario 1: Specific traffic isolation and control measures are essential in a network of EVPN L2VPN services or instances. Within a broadcast domain, services communicating with each other may result in flooding BUM traffic to all services within the domain. Moreover, hosts are learned and advertised between different sites/services.

Use Case 1: Implementing an EVPN E-Tree solution defines the network topology with distinct Root and Leaf classifications, BUM traffic flooding can be minimized, and traffic isolation can be achieved. This ensures efficient communication between services while preventing unnecessary traffic propagation and maintaining network integrity.

Scenario 2: An Internet Service Provider (ISP) provides services to multiple subscribers and aims to facilitate communication with them. However, the ISP needs to ensure that subscribers exclusively communicate with the ISP and not among themselves.

Use Case 2: Implementing EVPN E-Tree is essential to fulfill this requirement. By categorizing ISP services as Root and subscribers as Leaf, traffic isolation can be enforced. This configuration enables the ISP to communicate with subscribers while preventing inter-subscriber communication. As a result, network security is enhanced, and the ISP maintains control over communication within its network.

E-Tree CLI Commands

The EVPN E-Tree introduces the following configuration commands in OcNOS.

evpn etree

Use this command to enable E-Tree functionality within the EVPN configuration.

Command Syntax

```
evpn etree enable
```

Parameters

None

Default

Disabled

Command Mode

Configure mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example illustrates how to activate E-Tree functionality for EVPN:

```
OcNOS#configure terminal
OcNOS(config)#evpn etree enable
```

Revised CLI Commands

The following is the revised command for configuring MPLS EVPN E-Tree

evpn mpls id

- The existing syntax now includes the newly added parameter for E-Tree, namely `etree-leaf`.
- The command `evpn mpls id <ID> etree-leaf` allows users to tailor MPLS EVPN behavior on a network device, indicating its participation as a leaf node in an E-Tree deployment. For more details, refer to the [evpn mpls id](#) command in the [EVPN MPLS Commands](#) chapter in the *OcNOS Multi-Protocol Label Switching Guide*.

Troubleshooting

1. When traffic, whether unicast (UC) or broadcast, is passed to the Intra Leaf site:
 - Check the sub-interface or physical interface counters to monitor traffic throughput and potential issues.
 - Verify the Leaf status of the corresponding VNI to ensure proper functionality.
 - Use packet sniffing tools to analyze packets in the egress direction for any anomalies or errors.
 - MAC entries learned via leaf access port should include the `set` keyword in the MAC table output.
2. If UC traffic is routed within inter-PE leaf sites:
 - Check the Leaf status of the VNI at both participating PE devices to confirm operational status.
 - Check if the advertised MAC is in discard or non-discard status using the `show mac table` command and `12 show` in the BCM shell.
3. Verify if BUM traffic is transmitted between Leaf sites inter-PE:
 - Ensure that a BUM tunnels are not established between inter-PE devices.
 - Validate this by examining the Multicast ingress group, using the `show evpn mpls tunnel` command. For EVPN MPLS, confirm that BUM tunnels are not created.
4. Investigate UC traffic drops from the Root to MH Leaf PE:

- Check if MAC addresses are not installed in discard status within the MH peer's access port. This status could indicate issues with MAC learning or forwarding.
5. Evaluate traffic between Root and Leaf:
 - Confirm the establishment of both UC and BUM tunnels.
 - Ensure that unicast MAC addresses are not marked with a discard status in the MAC table.
 6. Validate the exchange of routes between two BGP L2VPN peers:
 - Monitor BGP (Border Gateway Protocol) sessions to verify successful route exchange and propagation between the peers.
 7. Convergence: Assess convergence by checking BFD configuration between BGP sessions.

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
EVPN E-Tree (Ethernet VPN Ethernet-Tree)	A networking solution designed to manage communication within broadcast domains, incorporating redundancy through multi-homing in a network. It optimizes traffic routing and control, categorizing network nodes based on predefined definitions of EVPN Instances as Leaf or Root, allowing or restricting communication between them.
EVPN (Ethernet Virtual Private Network)	A Layer 2 VPN technology that extends Ethernet services across data centers and wide-area networks using BGP.
Multi-homing (MH)	The ability of a device to connect to multiple network segments simultaneously to increase network availability and redundancy.
Provider Edge (PE) Node	A device at the edge of a service provider network that connects to customer premises equipment (CE) and participates in providing services to customers.
Leaf Node	In the context of EVPN E-Tree, a network node categorized to handle communication within specific broadcast domains and may connect to Root nodes.
Root Node	A network node within EVPN E-Tree that serves as the central point of communication and handles BUM traffic distribution.
Ethernet Segment Identifier (ESI)	A unique identifier used to identify Ethernet segments within a MPLS network.

CHAPTER 5 TWAMP over EVPN Configuration

This chapter contains a complete sample TWAMP over EVPN configuration.

Two-way Active Measurement Protocol (TWAMP) is an open protocol for measuring network performance between any two devices. The TWAMP MPLS transport is implemented as part of supporting TWAMP on routers which acts as MPLS routers both in the roles of LERs as well as intermediate routers. Ocnos 6.0 also supports the end to end statistics calculation when multiple paths are available between sender and reflector with multihop support.

The user can use the link delay metrics such as average, minimum, and maximum delay, and delay variance to determine the network latency. Using link delay metrics will enable troubleshooting latency issues or apply Traffic Engineering (TE) solutions to meet Service Level Agreements (SLAs).

The TWAMP protocol is designed to do such measurements, and a basic implementation of this protocol has already been implemented in ocnos. This feature here is a TWAMP protocol in ocnos where the focus will be on accuracy and configurable advertisement of the measured data.

EVPN (based on MPLS) Supported scenarios:

In general, TWAMP over EVPN works on,

- CE-CE Overlay Only
- CE-PE Overlay Only
- PE-PE Both Under lay and over lay

Topology

Figure 5-9 displays a sample TWAMP over EVPN topology.

- CE1 and CE2 are customer edge routers
- PE1 and PE2 are IPv4 Provider Edge routers
- P1 is the router at the core of the IPv4 MPLS provider network

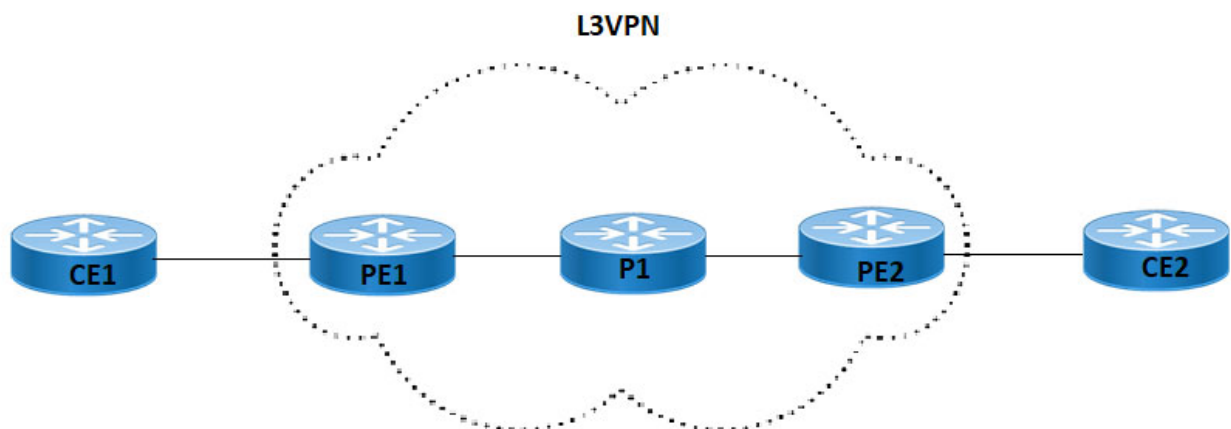


Figure 5-9: TWAMP over EVPN Topology

Configure TWAMP over EVPN for LDP

EVPN-Eline configurations

PE1

#configure terminal	Enter Configure mode.
(config)# evpn mpls enable	Enable EVPN MPLS
(config)# evpn mpls vtep-ip-global 18.18.18.18	Configuring VTEP global IP to loopback IP
(config)# mac vrf eline500	Create a new mac VRF named eline100
(config-vrf)# rd 20.20.20.20:100	Assign the route distinguisher (RD) value as 20.20.20.20:100
(config-vrf)# route-target both 111:111	Configuring import and export value as 111:111 Support: route-target export route-target import
(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the configurations
9config)# evpn mpls id 500 xconnect tar-get-mpls-id 501	Configure the EVPN-VPWS identifier with source identifier 2 and target identifier 501
(con-fig-evpn-mpls)#host-reachability-protocol evpn-bgp eline500	Mapping vrf "eline500" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 18.18.18.18	Configure router id as loopback address
(config-router)#transport-address ipv4 18.18.18.18	Configure ldp transport address as loopback address
(config-router)#exit	Exit from the router ldp mode
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 18.18.18.18/32 secondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#interface xe8	Enter Interface mode
(config-if)# ip address 10.1.1.18/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode
(config)#interface xe11.500 switchport	Creating L2 sub interface of physical interface xe11
(config-if)# encapsulation dot1q 500	Setting Encapsulation to dot1q with VLAN ID 2 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 500	Map vpn-id 500 to interface xe11.500 (VPWS)

(config-if)#exit	Exit interface mode
(config)# router ospf 1	Enter Router OSPF mode
(config-router)# ospf router-id 18.18.18.18	Configure OSPF router-id
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# network 18.18.18.18/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# commit	Commit the configurations
(config-router)# exit	Exit from router OSPF mode
(config)# router bgp 100	Enter BGP router mode
(config-router)# bgp router-id 18.18.18.18	Configure BGP router-id
(config-router)# neighbor 8.8.8.8 remote-as 100	Configure PE2 as an iBGP4+ neighbor
(config-router)# neighbor 8.8.8.8 up-date-source lo	Update the source as loopback for iBGP peering with the remote PE2 router
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 8.8.8.8 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exit form address family
(config-router)# commit	Commit the configurations

P1

#configure terminal	Enter Configure mode.
(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 3.3.3.3	Configure router id as loopback address
(config-router)#transport-address ipv4 3.3.3.3	Configure ldp transport address as loopback address
(config-router)#exit	Exit from the router ldp mode
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Assign IP address to Loopback interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode
(config)#interface xe14	Enter Interface mode
(config-if)# ip address 10.1.1.3/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode
(config)#interface xe15	Enter Interface mode
(config-if)# ip address 11.1.1.3/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface

(config-if)#exit	Exit interface mode
(config)# router ospf 1	Enter Router OSPF mode
(config-router)# ospf router-id 18.18.18.18	Configure OSPF router-id
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# network 11.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# commit	Commit the configurations
(config-router)# exit	Exit from router OSPF mode

PE2

#configure terminal	Enter Configure mode.
(config)# evpn mpls enable	Enable EVPN MPLS
(config)# evpn mpls vtep-ip-global 8.8.8.8	Configuring VTEP global IP to loopback IP
(config)# mac vrf eline500	Create a new mac VRF named eline100
(config-vrf)# rd 20.20.20.20:100	Assign the route distinguisher (RD) value as 20.20.20.20:100
(config-vrf)# route-target both 111:111	Configuring import and export value as 111:111 Support: route-target export route-target import
(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the configurations
9config)# evpn mpls id 501 xconnect tar-get-mpls-id 500	Configure the EVPN-VPWS identifier with source identifier 501 and target identifier 500
(con-fig-evpn-mpls)#host-reachability-protocol evpn-bgp eline500	Mapping vrf "eline500" to EVPN-VPWS identifier
(config-evpn-mpls)#exit	Exit from evpn mpls mode
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 8.8.8.8/32 secondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 8.8.8.8	Configure router id as loopback address
(config-router)#transport-address ipv4 8.8.8.8	Configure ldp transport address as loopback address
(config-router)#exit	Exit from the router ldp mode
(config)#interface xe24	Enter Interface mode
(config-if)# ip address 11.1.1.8/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode
(config)#interface xe25	Enter Interface mode

(config-if)# ip vrf forwarding vrf100	Bind the interface connected to the CE1 router with VRF 100
(config-if)# ip address 101.1.1.1/24	Assign IP address to interface
(config-if)#exit	Exit interface mode
(config)# router ospf 1	Enter Router OSPF mode
(config-router)# ospf router-id 8.8.8.8	Configure OSPF router-id
(config-router)# network 11.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# network 8.8.8.8/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit from router OSPF mode
(config)# router bgp 100	Enter BGP router mode
(config-router)# bgp router-id 8.8.8.8	Configure BGP router-id
(config-router)# neighbor 18.18.18.18 remote-as 100	Configure PE2 as an iBGP4+ neighbor
(config-router)# neighbor 18.18.18.18 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 8.8.8.8 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exit form address family
(config-router)# commit	Commit the configurations

CE1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 37.37.37.37/32 secondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#interface xe24.500	Enter Interface mode
(config-if)#encapsulation dot1q 500	Setting Encapsulation to dot1q with VLAN ID 500
(config-if)# ip address 172.16.10.1/24	Configure IP address on the interface
(config-if)#exit	Exit Interface mode
(config)# router bgp 200	Enter BGP router mode
(config-router)# bgp router-id 37.37.37.37	Configure BGP router-id
(config-router)#neighbor 100.1.1.1 remote-as 100	Configure PE1 as an eBGP4+ neighbor
(config-router)# address-family ipv4 unicast	Enter address-family IPv4 unicast mode
(config-router-af)# redistribute connected	Redistribute the connected route under address family IPv4 unicast
(config-router-af)# neighbor 100.1.1.1 activate	Activate the neighbor in the IPv4 address family

(config-router-af)#exit	Exit form address family
(config-router)# commit	Commit the configurations

CE2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 2.2.2.2/32 secondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#interface xe14.500	Enter Interface mode
(config-if)#encapsulation dot1q 500	Setting Encapsulation to dot1q with VLAN ID 500
(config-if)# ip address 172.16.10.2/24	Assign IP address to interface
(config-if)#exit	Exit Interface mode
(config)# router bgp 300	Enter BGP router mode
(config-router)# bgp router-id 2.2.2.2	Configure BGP router-id
(config-router)#neighbor 101.1.1.1 remote-as 100	Configure PE2 as an eBGP4+ neighbor
(config-router)# address-family ipv4 unicast	Enter address-family IPv4 unicast mode
(config-router-af)# redistribute connected	Redistribute the connected route under address family IPv4 unicast
(config-router-af)# neighbor 101.1.1.1 activate	Activate the neighbor in the IPv4 address family
(config-router-af)#exit	Exit form address family
(config-router)# commit	Commit the configurations

TWAMP Configuration on Sender (CE1)

TWAMP sender is configured to measure the delay on interface xe24.500 CE1

#configure terminal	Enter Configure mode.
(config)# hardware-profile filter twamp-ipv4 enable	Enable hardware filter for ipv4 to configure TWAMP measurement configs
(config)#commit	Commit the configuration
(config)# twamp-light control	Enable TWAMP light controller on CE1
(config-twamp-light-con)# control-admin-state enable	Enable TWAMP Controller admin state
(config)# interface xe24.500	Enter Interface Loopback mode
(config-if)# delay-measurement dynamic twamp reflector-ip 172.16.10.2	Configure delay measurement on interface to reflector CE2
(config-if)#commit	Commit the configurations
(config-if)#end	Return to privilege mode

TWAMP Configuration on Reflector (CE2)

Configure TWAMP Reflector as interface xe24.500 on CE2

#configure terminal	Enter Configure mode.
(config)# hardware-profile filter twamp-ipv4 enable	Enable hardware filter for ipv4 to configure TWAMP measurement configs
(config)#commit	Commit the configuration
(config)# twamp-light reflector	Enable TWAMP light Reflector on CE2
(config-twamp-light-ref)# reflec-tor-admin-state enable	Enable the TWAMP reflector admin state
(config-twamp-light-ref)# reflector-name pe2 reflector-ip ipv4 172.16.10.2	Configure TWAMP reflector IP as CE2 interface IP
(config-twamp-light-ref)#commit	Commit the configurations
(config-if)#end	Return to privilege mode

Validation

1. Verify ping from CE1 to CE2

```
PE1#ping 172.16.10.2
Press CTRL+C to exit
PING 172.16.10.2 (172.16.10.2) 56(84) bytes of data.
64 bytes from 172.16.10.2: icmp_seq=1 ttl=64 time=0.776 ms
    64 bytes from 172.16.10.2: icmp_seq=2 ttl=64 time=0.553 ms
```

2. Verify the TWAMP statistics on all the configured interfaces on CE1

In the below verification command, packets sent and received showing as equal. So all the TWAMP packets received reply for all the sent packets for the delay measurement. Showing all the Round Trip Delay and Reverse Delay timers.

```
PE1#sh twamp-statistics
=====
TWAMP Test-Session Statistics
=====
Test-Session Name      : __internal_interface_xe24.500
Start Time             : 2023 Mar 16 00:04:37
Elapsed time(milli sec) : 3001
Packets Sent           : 1
Packets Received       : 1
Packet Loss(%)         : 0.00
Round Trip Delay(usec)
    Minimum            : 383
    Maximum            : 383
    Average            : 383
Forward Delay(usec)
    Minimum            : (*)
    Maximum            : (*)
    Average            : (*)
Reverse Delay(usec)
```

```

Minimum          : (*)
Maximum          : (*)
Average          : (*)
Round Trip Delay Variation(usec)
Minimum          : 383
Maximum          : 383
Average          : 383
Forward Delay Variation(usec)
Minimum          : (*)
Maximum          : (*)
Average          : (*)
Reverse Delay Variation(usec)
Minimum          : (*)
Maximum          : (*)
Average          : (*)

```

(*) - Time is not in sync between Sender and Reflector

3. Verify the List of all interfaces that are currently participating in Delay measurement

```
PE1#sh twamp-statistics interfaces
```

Interface	Last Advertisement	Delay(us)	Min(us)	Max(us)	Var(us)	Loss(%)
xe24.500	-	0	0	0	0	Not Enabled

4. Verify the Detailed list of TWAMP delay measurement information on interface Loopback

```
PE1#sh twamp-statistics interfaces xe24.500
```

```

Interface name    : xe24.500
Sender IP         : 172.16.10.1
Reflector IP      : 172.16.10.2
Reflector port    : 862
DSCP value        : 0
HW Status         : HW rules installed

```

Last Advertised stats:

```

Time: 2023-03-16 00:05:08
Average delay      : 198
Minimum delay      : 166
Maximum delay      : 233
Average delay variation: 5
Minimum delay variation: 2
Maximum delay variation: 10
Packets sent       : 10
Packets received   : 10
Packets timeout    : 0
Packet Loss: Not Enabled

```

Last Calculated stats:

```

Time: 2023-03-16 00:05:08
Average delay      : 198
Minimum delay      : 166
Maximum delay      : 233
Average delay variation: 5

```

Minimum delay variation: 2
Maximum delay variation: 10
Packets sent : 10
Packets received : 10
Packets timeout : 0
Packet Loss : Not Enabled

IPv6 Provider Edge Routers (6PE) /MPLS VPN Configuration

CHAPTER 1 6PE Configuration

This chapter explains about IPv6 islands over IPv4 MPLS using IPv6 Provider Edge Routers (6PE). With this technique, IPv6 islands are connected to each other across an IPv4 backbone enabled with MPLS label stacking while MP-BGP is used to announce the IPv6 routes across these MPLS tunnels. This feature can be implemented with label-switched paths (LSPs) using the Label Distribution Protocol (LDP) or Resource Reservation Protocol (RSVP).

This feature offers the following options to the service providers:

- Connect to other IPv6 networks accessible across the MPLS core.
- Provide access to IPv6 services and resources that service provider provides.
- Provide IPv6 VPN services without going for complete overhaul of existing MPLS/IPv4 core.

The 6PE uses the existing IPv4 MPLS core infrastructure for IPv6 transport. It enables IPv6 sites to communicate with each other over an IPv4 MPLS core network using MPLS label switched paths (LSPs). This feature relies heavily on multiprotocol Border Gateway Protocol (BGP) extensions in the IPv4 network configuration on the provider edge (PE) router to exchange IPv6 reachability information (in addition to an MPLS label) for each IPv6 address prefix. Edge routers are configured as dual-stack, running both IPv4 and IPv6, and use the IPv4 mapped IPv6 address for IPv6 prefix reachability exchange.

Benefits of 6PE

6PE offers the following benefits to service providers:

- Minimal operational cost and risk - No impact on existing IPv4 and MPLS services.
- Only provider edge routers require upgrade - A 6PE router can be an existing PE router or a new one dedicated to IPv6 traffic.
- No impact on IPv6 customer edge (CE) routers - The ISP can connect to any CE router running Static, IGP or EGP.
- Production services ready - An ISP can delegate IPv6 prefixes.
- IPv6 introduction into an existing MPLS service - 6PE routers can be added at any time.

IPv6 on Provider Edge Routers

The 6PE is a technique that provides global IPv6 reachability over IPv4 MPLS. It allows one shared routing table for all other devices. 6PE allows IPv6 domains to communicate with one another over the IPv4 without an explicit tunnel setup, requiring only one IPv4 address per IPv6 domain. While implementing 6PE, the provider edge routers are upgraded to support 6PE, while the rest of the core network is not touched (IPv6 unaware).

This implementation requires no re-configuration of core routers because forwarding is based on labels rather than on the IP header itself. This provides a cost-effective strategy for deploying IPv6. The IPv6 reachability information is exchanged by PE routers using multi-protocol Border Gateway Protocol (mp-iBGP) extensions. 6PE relies on mp-iBGP extensions in the IPv4 network configuration on the PE router to exchange IPv6 reachability information in addition to an MPLS label for each IPv6 address prefix to be advertised. PE routers are configured as dual stacks, running both IPv4 and IPv6, and use the IPv4 mapped IPv6 address for IPv6 prefix reachability exchange. The next hop advertised by the PE router for 6PE prefixes is still the IPv4 address that is used for IPv4 L3 VPN routes.

The following figure illustrates the 6PE topology.

Topology

As shown in [Figure 1-10](#):

- CE1 and CE2 are customer edge routers
- 6PE1 and 6PE2 are IPv6 Provider Edge routers
- P is the router at the core of the IPv4 MPLS provider network

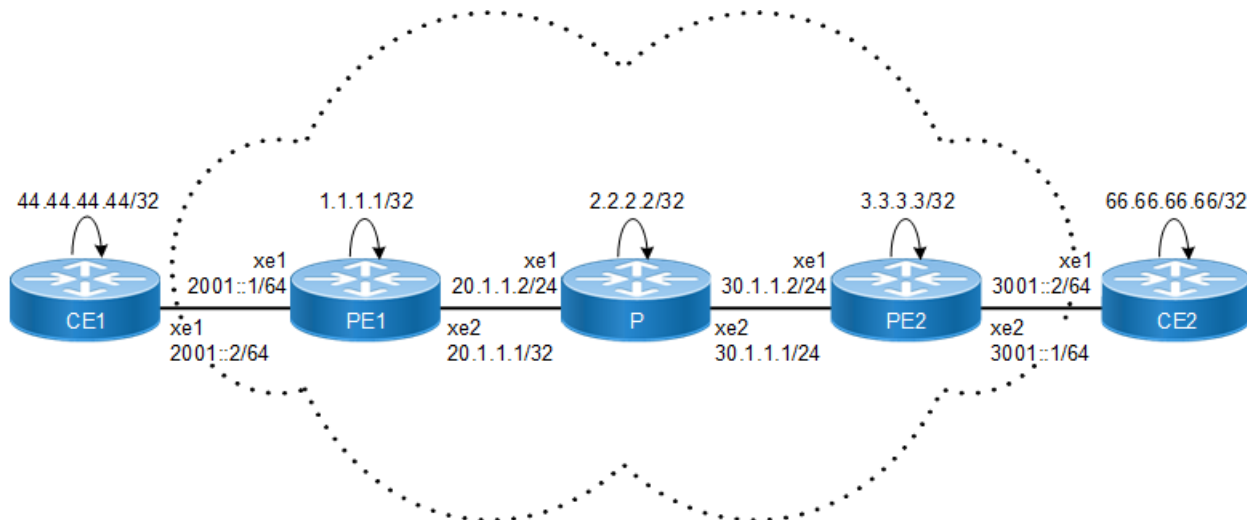


Figure 1-10: 6PE Configuration

Configuration

CE1

#configure terminal	Enter configure mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 44.44.44.44/32 secondary	Assign the IPv4 address
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter interface mode.
(config-if)#ipv6 address 2001::2/64	Assign the IPv6 address.
(config-if)#exit	Exit interface mode.
(config)#router bgp 200	Enter router BGP mode.
(config-router)#bgp router-id 44.44.44.44	Assign router ID
(config-router)#neighbor 2001::1 remote-as 100	Configure 6PE1 as an eBGP4+ neighbor.
(config-router)#address-family ipv6 unicast	Enter Address-Family IPv6 unicast mode
(config-router-af)#redistribute static	Redistribute static routes
(config-router-af)#neighbor 2001::1 activate	Activate the neighbor in the IPv6 address family
(config-router-af)#exit	Exit address family

(config-router)#ipv6 route 2ffe::/64 xe1	Configure IPV6 static route
(config-router)#commit	Commit the transaction

CE2

#configure terminal	Enter configure mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 66.66.66.66/32 secondary	Assign the IPv4 address
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter Interface mode
(config-if)#ipv6 address 3002::2/64	Assign IPv6 address
(config-if)#exit	Exit interface mode
(config)#router bgp 300	Enter BGP configure mode
(config-router)#bgp router-id 66.66.66.66	Assign router ID
(config-router)#neighbor 3002::1 remote-as 100	Configure 6PE2 as an eBGP4+ neighbor.
(config-router)#address-family ipv6 unicast	Enter Address-Family IPv6 unicast mode
(config-router-af)#redistribute static	Redistribute static routes
(config-router-af)#neighbor 3002::1 activate	Activate the neighbor in the IPv6 address family.
(config-router-af)#exit	Exit address family
(config-router)#ipv6 route 3ffe::/64 xe1	Configure IPV6 static route
(config-router)#commit	Commit the transaction

PE1

#configure terminal	Enter configure mode
(config)#interface xe1	Enter Interface mode
(config-if)#ipv6 address 2001::1/64	Assign IPv6 address
(config-if)#exit	Exit interface mode
(config)#interface lo	Enter Interface mode
(config-if)#ip address 1.1.1.1/32 secondary	Assign the IP address to loopback interface
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router ldp mode.
(config-router)#router-id 1.1.1.1	Configure router-id
(config-router)#explicit-null	Configure explicit-null.
(config-router)#transport-address ipv4 1.1.1.1	Configure transport address as loopback address
(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted peer
config-router-targeted-peer)#exit	Exit router targeted mode
(config-router)#exit	Exit LDP mode
(config)#interface xe2	Enter Interface mode
(config-if)#ip address 20.1.1.1/24	Assign IPv4 address
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable ldp in interface.

(config-if)#exit	Exit interface mode
(config)#router ospf	Enter router ospf mode.
(config-router)#ospf router-id 1.1.1.1	Configure ospf router id same as loopback ip address.
(config-router)#network 1.1.1.1/32 area 0 (config-router)#network 20.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit from router ospf mode.
(config)#mpls label mode 6pe per-prefix	Change label mode to per-prefix, default is per VRF
(config)#router bgp 100	Enter BGP Configure mode.
(config-router)#bgp router-id 1.1.1.1	Configure BGP router-id
(config-router)#neighbor 3.3.3.3 remote-as 100	Configure 6PE2 as an iBGP peer.
(config-router)#neighbor 3.3.3.3 update-source lo	Update the source as loopback for iBGP peering with the remote 6PE router.
(config-router)#neighbor 2001::2 remote-as 200	Configure CE1 as eBGP peer
(config-router)#address-family ipv4 unicast	Enter address family mode
(config-router-af)#neighbor 3.3.3.3 activate	Activate neighbor
(config-router-af)#exit	Exit address family mode
(config-router)#address-family ipv6 labeled-unicast	Enter IPv6 labeled-unicast Address Family mode.
(config-router-af)#neighbor 3.3.3.3 activate	Activate the 6PE neighbor
(config-router-af)#exit-address-family	Exit IPv6 LU Address Family mode.
(config-router)#address-family ipv6 unicast	Enter the IPv6 address family
(config-router-af)#neighbor 2001::2 activate	Activate CE inside IPv6 address family
(config-router-af)#redistribute connected	Redistribute the connected routes
(config-router-af)#exit	Exit IPv6 Address Family mode.
(config-router)#commit	Commit the transaction.

P1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 2.2.2.2/32 secondary	Assign the IP address to loopback interface
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router ldp mode.
(config-router)#router-id 2.2.2.2	Configure router-id
(config-router)#transport-address ipv4 2.2.2.2	Configure transport address as loopback address
(config-router)#exit	Exit router ldp mode.
(config)#router ospf	Enter router ospf mode.
(config-router)#ospf router-id 2.2.2.2	Configure ospf router id same as loopback ip address.
(config-router)#network 2.2.2.2/32 area 0 (config-router)#network 20.1.1.2/24 area 0 (config-router)#network 30.1.1.1/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit from router ospf mode.

(config)#interface xe2	Enter Interface mode
(config-if)#ip address 30.1.1.1/24	Assign IPv4 address
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable ldp in interface.
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter Interface mode
(config-if)#ip address 20.1.1.2/24	Assign IPv4 address
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable ldp in interface.
(config-if)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode
(config)#interface xe2	Enter Interface mode
(config-if)#ipv6 address 3002::1/64	Assign IPv6 address
(config-if)#exit	Exit interface mode
(config)#interface lo	Enter Interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Assign the IP address to loopback interface
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router ldp mode.
(config-router)#router-id 3.3.3.3	Configure router-id
(config-router)#transport-address ipv4 3.3.3.3	Configure transport address as loopback address
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#explicit-null	Configure explicit-null.
(config-router)#exit	Exit LDP mode
(config)#interface xe1	Enter Interface mode
(config-if)#ip address 30.1.1.2/24	Assign IPv4 address
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable ldp in interface.
(config-if)#exit	Exit interface mode
(config)#mpls label mode 6pe per-prefix	Change label mode to per-prefix, default is per VRF
(config)#router bgp 100	Enter router BGP mode.
(config-router)#bgp router-id 3.3.3.3	Configure BGP router id
(config-router)#neighbor 1.1.1.1 remote-as 100	Configure 6VPE2 as an iBGP peer.
(config-router)#neighbor 1.1.1.1 update-source lo	Update the source as loopback for iBGP peering with the remote 6VPE router.
(config-router)#address-family ipv4 unicast	Enter address family mode
(config-router-af)#neighbor 1.1.1.1 activate	Activate neighbor
(config-router-af)#exit	Exit address family mode
(config-router)#neighbor 3002::2 remote-as 300	Configure CE1 as eBGP peer

(config-router)#address-family ipv6 labeled-unicast	Enter IPv6 labeled-unicast Address Family mode.
(config-router-af)#neighbor 1.1.1.1 activate	Activate the 6PE neighbor
(config-router-af)#exit-address-family	Exit IPv6 LU Address Family mode.
(config-router)#address-family ipv6 unicast	Enter the IPv6 address family
(config-router-af)#neighbor 3002::2 activate	Activate CE inside IPv6 address family
(config-router-af)#redistribute connected	Redistribute the connected routes
(config-router-af)#exit-address-family	Exit IPv6 Address Family mode.
(config-router)#exit	Exit Router mode.
(config)#router ospf	Enter OSPF router mode
(config-router)#network 3.3.3.3/32 area 0	Enable OSPF with specified area ID on interfaces with IP address that matches the specified network address
(config-router)#network 30.1.1.0/24 area 0	Enable OSPF with specified area ID on interfaces with IP address that matches the specified network address
(config-router)#commit	Commit the transaction

Validation

CE1

```
CE1#show ipv6 route
IPv6 Routing Table
Codes: K - kernel route, C - connected, S - static, D- DHCP, R - RIP,
       O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
       E2 - OSPF external type 2, E - EVPN  N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, i - IS-IS, B - BGP,
       v - vrf leaked
Timers: Uptime
```

```
IP Route Table for VRF "default"
C      ::1/128 via ::, lo, 01:10:32
C      2001::/64 via ::, xe1, 00:46:49
S      2ffe::/64 [1/0] via ::, xe1, 00:35:20
B      3002::/64 [20/0] via fe80::5054:ff:fe29:189d, xe1, 00:02:12
B      3ffe::/64 [20/0] via fe80::5054:ff:fe29:189d, xe1, 00:02:36
C      fe80::/64 via ::, xe3, 01:10:32
#
```

```
CE1#show ipv6 bgp summary
BGP router identifier 44.44.44.44, local AS number 200
BGP table version is 8
3 BGP AS-PATH entries
0 BGP community entries
```

Neighbor	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
PfxRcd									
2001::1	4	100	80	83	8	0	0	00:01:45	
3									

Total number of neighbors 1

Total number of Established sessions 1

PE1

PE1#show ipv6 route

IPv6 Routing Table

Codes: K - kernel route, C - connected, S - static, D- DHCP, R - RIP,
 O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
 E2 - OSPF external type 2, E - EVPN N1 - OSPF NSSA external type 1,
 N2 - OSPF NSSA external type 2, i - IS-IS, B - BGP,
 v - vrf leaked

Timers: Uptime

IP Route Table for VRF "default"

```
C      ::1/128 via ::, lo, 01:17:11
C      2001::/64 via ::, xe1, 00:40:22
B      2ffe::/64 [20/0] via fe80::5054:ff:fe60:f4e5, xe1, 00:02:37
B      3002::/64 [200/0] via ::ffff:3.3.3.3, 00:03:10
B      3ffe::/64 [200/0] via ::ffff:3.3.3.3, 00:01:07
C      fe80::/64 via ::, xe2, 01:17:11
```

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe2	Passive	OPERATIONAL	30	00:06:59

PE1#show bgp ipv6

BGP table version is 5, local router ID is 1.1.1.1

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 1 2001::/64	::	0	100	32768	?
*> 1 2ffe::/64	2001::2(fe80::5054:ff:fe60:f4e5)	0	100	0	200 ?
*>i 3002::/64	::ffff:3.3.3.3	0	100	0	?
*>i 3ffe::/64	::ffff:3.3.3.3	0	100	0	300 ?

Total number of prefixes 4

PE1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					

```

L> 2.2.2.2/32      3      3      -      -      LSP_DEFAULT  3
xe2      No      20.1.1.2
L> 3.3.3.3/32      4      4      -      -      LSP_DEFAULT  24321
xe2      No      20.1.1.2
L> 30.1.1.0/24     5      3      -      -      LSP_DEFAULT  3
xe2      No      20.1.1.2
B> 3002::/64       2      2      0      Yes    LSP_DEFAULT  24960
-      No      3.3.3.3
B> 3ffe::/64       1      1      0      Yes    LSP_DEFAULT  24961
-      No      3.3.3.3

```

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe2	Passive	OPERATIONAL	30	00:06:59

PE1#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.1.1.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 4, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 4

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe2, out label: 24321

Nexthop addr: 20.1.1.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 30.1.1.0/24, id: 5, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.1.1.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 3002::/64, id: 2, row status: Active, Tunnel-Policy: N/A
 Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Transport Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
 Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
 Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
 Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 2, owner: BGP, Stale: NO, BGP out intf: xe2, transport out
 intf: xe2, out label: 24960
 Nexthop addr: 3.3.3.3 cross connect ix: 2, op code: Push and Lookup

Primary FTN entry with FEC: 3ffe::/64, id: 1, row status: Active, Tunnel-Policy: N/A
 Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
 none

Transport Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
 Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
 Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
 Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 1, owner: BGP, Stale: NO, BGP out intf: xe2, transport out
 intf: xe2, out label: 24961
 Nexthop addr: 3.3.3.3 cross connect ix: 1, op code: Push and Lookup

PE1#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, s - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nexthop		LSP-Type				
B>	2001::/64	3	24960	Nolabel	N/A	N/A
127.0.0.1		LSP_DEFAULT				
B>	2ffe::/64	4	24961	Nolabel	N/A	N/A
127.0.0.1		LSP_DEFAULT				
#						

PE1#show ip bgp summary

BGP router identifier 1.1.1.1, local AS number 100
 BGP table version is 1
 3 BGP AS-PATH entries
 0 BGP community entries

Neighbor	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
PfxRcd									
3.3.3.3	4	100	42	43	1	0	0	00:08:40	
0									

Total number of neighbors 1

Total number of Established sessions 1

PE1#show ipv6 bgp summary

BGP router identifier 1.1.1.1, local AS number 100
 BGP table version is 5
 3 BGP AS-PATH entries
 0 BGP community entries

Neighbor PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
2001::2	4	200	93	98	5	0	0	00:08:33	
1									

Total number of neighbors 1

Total number of Established sessions 1

PE1#show ip bgp neighbors

BGP neighbor is 3.3.3.3, remote AS 100, local AS 100, internal link
 BGP version 4, local router ID 1.1.1.1, remote router ID 3.3.3.3
 BGP state = Established, up for 00:08:55
 Last read 00:00:21, hold time is 90, keepalive interval is 30 seconds
 Neighbor capabilities:
 Route refresh: advertised and received (old and new)
 Address family IPv4 Unicast: advertised and received
 Address family IPv6 Labeled Unicast: advertised and received
 Received 42 messages, 0 notifications, 0 in queue
 Sent 43 messages, 1 notifications, 0 in queue
 Route refresh request: received 0, sent 0
 Minimum time between advertisement runs is 5 seconds
 Update source is lo
 For address family: IPv4 Unicast
 BGP table version 1, neighbor version 1
 Index 1, Offset 0, Mask 0x2
 Community attribute sent to this neighbor (both)
 0 accepted prefixes
 0 announced prefixes

For address family: IPv6 Labeled-Unicast
 BGP table version 6, neighbor version 6
 Index 1, Offset 0, Mask 0x2
 Community attribute sent to this neighbor (both)
 2 accepted prefixes
 2 announced prefixes

Connections established 2; dropped 1
 Local host: 1.1.1.1, Local port: 34293
 Foreign host: 3.3.3.3, Foreign port: 179
 Nexthop: 1.1.1.1
 Nexthop global: ::
 Nexthop local: ::
 BGP connection: non shared network
 Last Reset: 00:09:51, due to Administratively Reset (Cease Notification sent)
 Notification Error Message: (Cease/Administratively Reset.)

```

BGP neighbor is 2001::2, remote AS 200, local AS 100, external link
  BGP version 4, local router ID 1.1.1.1, remote router ID 44.44.44.44
  BGP state = Established, up for 00:08:45
  Last read 00:00:16, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv6 Unicast: advertised and received
  Received 92 messages, 1 notifications, 0 in queue
  Sent 97 messages, 1 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 30 seconds
For address family: IPv6 Unicast
  BGP table version 5, neighbor version 5
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  1 accepted prefixes
  3 announced prefixes

```

```

Connections established 3; dropped 2
Local host: 2001::1, Local port: 179
Foreign host: 2001::2, Foreign port: 40980
Nexthop: 1.1.1.1
Nexthop global: 2001::1
Nexthop local: fe80::5054:ff:fe29:189d
BGP connection: shared network
Last Reset: 00:08:50, due to BGP Notification received
Notification Error Message: (Cease/Other Configuration Change.)

```

P1

```
P1#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
3.3.3.3	xe1	Passive	OPERATIONAL	30	00:10:11
1.1.1.1	xe2	Active	OPERATIONAL	30	00:09:21

```
P1#show mpls forwarding-table
```

```

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	1.1.1.1/32	2	2	-	-	LSP_DEFAULT	0
xe2	No	20.1.1.1					
L>	3.3.3.3/32	1	1	-	-	LSP_DEFAULT	0
xe1	No	30.1.1.2					

```
P1#show mpls ilm-table
```

```

Codes: > - installed ILM, * - selected ILM, p - stale ILM
       K - CLI ILM, T - MPLS-TP, s - Stitched ILM

```

S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nexthop		LSP-Type				
L>	3.3.3.3/32	2	24321	0	N/A	xe1
30.1.1.2		LSP_DEFAULT				
L>	1.1.1.1/32	1	24320	0	N/A	xe2
20.1.1.1		LSP_DEFAULT				

PE2

PE2#show ipv6 route

IPv6 Routing Table

Codes: K - kernel route, C - connected, S - static, D- DHCP, R - RIP,
 O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
 E2 - OSPF external type 2, E - EVPN N1 - OSPF NSSA external type 1,
 N2 - OSPF NSSA external type 2, i - IS-IS, B - BGP,
 v - vrf leaked

Timers: Uptime

IP Route Table for VRF "default"

C	::1/128 via ::, lo, 01:24:48
B	2001::/64 [200/0] via ::ffff:1.1.1.1, 00:11:08
B	2ffe::/64 [200/0] via ::ffff:1.1.1.1, 00:10:34
C	3002::/64 via ::, xe2, 00:24:41
B	3ffe::/64 [20/0] via fe80::5054:ff:fef6:c35d, xe2, 00:09:07
C	fe80::/64 via ::, xe3, 01:24:48

PE2#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, s - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nexthop		LSP-Type				
B>	3002::/64	3	24960	Nolabel	N/A	N/A
127.0.0.1		LSP_DEFAULT				
B>	3ffe::/64	4	24961	Nolabel	N/A	N/A
127.0.0.1		LSP_DEFAULT				

PE2#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nextthop					
L>	1.1.1.1/32	3	2	-	-	LSP_DEFAULT	24320
xel	No	30.1.1.1					
L>	2.2.2.2/32	1	1	-	-	LSP_DEFAULT	3
xel	No	30.1.1.1					
L>	20.1.1.0/24	2	1	-	-	LSP_DEFAULT	3
xel	No	30.1.1.1					
B>	2001::/64	4	3	0	Yes	LSP_DEFAULT	24960
-	No	1.1.1.1					
B>	2ffe::/64	5	4	0	Yes	LSP_DEFAULT	24961
-	No	1.1.1.1					

PE2#show mpls ftn-table

Primary FTN entry with FEC: 1.1.1.1/32, id: 3, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xel, out label: 24320

Nextthop addr: 30.1.1.1 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xel, out label: 3

Nextthop addr: 30.1.1.1 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 20.1.1.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xel, out label: 3

Nextthop addr: 30.1.1.1 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 2001::/64, id: 4, row status: Active, Tunnel-Policy: N/A
 Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Transport Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 3, owner: BGP, Stale: NO, BGP out intf: xel, transport out
 intf: xel, out label: 24960
 Nexthop addr: 1.1.1.1 cross connect ix: 4, op code: Push and Lookup

Primary FTN entry with FEC: 2ffe::/64, id: 5, row status: Active, Tunnel-Policy: N/A
 Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
 none
 Transport Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
 Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
 Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 4
 Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 4, owner: BGP, Stale: NO, BGP out intf: xel, transport out
 intf: xel, out label: 24961
 Nexthop addr: 1.1.1.1 cross connect ix: 5, op code: Push and Lookup

PE2#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xel	Active	OPERATIONAL	30	00:12:01

PE2#show bgp ipv6

BGP table version is 5, local router ID is 3.3.3.3
 Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
 internal,
 l - labeled, S Stale
 Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
*>i 2001::/64	::ffff:1.1.1.1	0	100	0	?
*>i 2ffe::/64	::ffff:1.1.1.1	0	100	0	200 ?
*> l 3002::/64	::	0	100	32768	?
*> l 3ffe::/64	3002::2(fe80::5054:ff:fef6:c35d)	0	100	0	300 ?

Total number of prefixes 4

PE2#show ip bgp neighbors

BGP neighbor is 1.1.1.1, remote AS 100, local AS 100, internal link
 BGP version 4, local router ID 3.3.3.3, remote router ID 1.1.1.1
 BGP state = Established, up for 00:11:54
 Last read 00:00:06, hold time is 90, keepalive interval is 30 seconds
 Neighbor capabilities:
 Route refresh: advertised and received (old and new)
 Address family IPv4 Unicast: advertised and received
 Address family IPv6 Labeled Unicast: advertised and received
 Received 50 messages, 0 notifications, 0 in queue
 Sent 50 messages, 1 notifications, 0 in queue
 Route refresh request: received 0, sent 0
 Minimum time between advertisement runs is 5 seconds
 Update source is lo

For address family: IPv4 Unicast
BGP table version 1, neighbor version 1
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (both)
0 accepted prefixes
0 announced prefixes

For address family: IPv6 Labeled-Unicast
BGP table version 5, neighbor version 5
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (both)
2 accepted prefixes
2 announced prefixes

Connections established 2; dropped 1
Local host: 3.3.3.3, Local port: 179
Foreign host: 1.1.1.1, Foreign port: 34293
Nexthop: 3.3.3.3
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
Last Reset: 00:12:28, due to Administratively Reset (Cease Notification sent)
Notification Error Message: (Cease/Administratively Reset.)

BGP neighbor is 3002::2, remote AS 300, local AS 100, external link
BGP version 4, local router ID 3.3.3.3, remote router ID 66.66.66.66
BGP state = Established, up for 00:10:17
Last read 00:00:25, hold time is 90, keepalive interval is 30 seconds
Neighbor capabilities:

Route refresh: advertised and received (old and new)
Address family IPv6 Unicast: advertised and received

Received 61 messages, 2 notifications, 0 in queue
Sent 68 messages, 2 notifications, 0 in queue
Route refresh request: received 0, sent 0
Minimum time between advertisement runs is 30 seconds

For address family: IPv6 Unicast
BGP table version 5, neighbor version 5
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (both)
1 accepted prefixes
3 announced prefixes

Connections established 3; dropped 2
Local host: 3002::1, Local port: 52758
Foreign host: 3002::2, Foreign port: 179
Nexthop: 3.3.3.3
Nexthop global: 3002::1
Nexthop local: fe80::5054:ff:fe2b:8d4f
BGP connection: shared network
Last Reset: 00:10:22, due to BGP Notification received

Notification Error Message: (Cease/Other Configuration Change.)

```
PE2#show ip bgp summary
BGP router identifier 3.3.3.3, local AS number 100
BGP table version is 1
3 BGP AS-PATH entries
0 BGP community entries
```

Neighbor PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
1.1.1.1	4	100	50	52	1	0	0	00:12:06	
0									

Total number of neighbors 1

Total number of Established sessions 1

```
PE2#show ipv6 bgp summary
BGP router identifier 3.3.3.3, local AS number 100
BGP table version is 5
3 BGP AS-PATH entries
0 BGP community entries
```

Neighbor PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
3002::2	4	300	64	70	5	0	0	00:10:31	
1									

Total number of neighbors 1

Total number of Established sessions 1

CE2

```
CE2#show ipv6 bgp summary
BGP router identifier 66.66.66.66, local AS number 300
BGP table version is 9
3 BGP AS-PATH entries
0 BGP community entries
```

Neighbor PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
3002::1	4	100	70	67	9	0	0	00:11:35	
3									

Total number of neighbors 1

Total number of Established sessions 1

```
CE2#show ipv6 route
IPv6 Routing Table
Codes: K - kernel route, C - connected, S - static, D- DHCP, R - RIP,
       O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
```

E2 - OSPF external type 2, E - EVPN N1 - OSPF NSSA external type 1,
N2 - OSPF NSSA external type 2, i - IS-IS, B - BGP,
v - vrf leaked

Timers: Uptime

IP Route Table for VRF "default"

C ::1/128 via ::, lo, 01:26:48
B 2001::/64 [20/0] via fe80::5054:ff:fe2b:8d4f, xe2, 00:11:43
B 2ffe::/64 [20/0] via fe80::5054:ff:fe2b:8d4f, xe2, 00:11:43
C 3002::/64 via ::, xe2, 00:24:47
S 3ffe::/64 [1/0] via ::, xe2, 00:24:05
C fe80::/64 via ::, xe2, 01:26:48

CHAPTER 2 6VPE Configuration

This chapter explains how 6VPE (IPv6 on VPN Provider Edge Routers) can interconnect IPv6 islands over an MPLS-enabled IPv4 cloud. 6VPE enables IPv6 sites to communicate with each other over an MPLS/IPv4 core network using MPLS LSPs. The 6VPE routers exchange IPv6 reachability information over the core using Multi-Protocol Border Gateway Protocol (MP-BGP) over IPv4.

Topology

As shown in [Figure 2-11](#):

- CE1 and CE2 are customer edge routers
- 6VPE1 and 6VPE2 are IPv6 Provider Edge routers
- P is the router at the core of the IPv4 MPLS provider network.

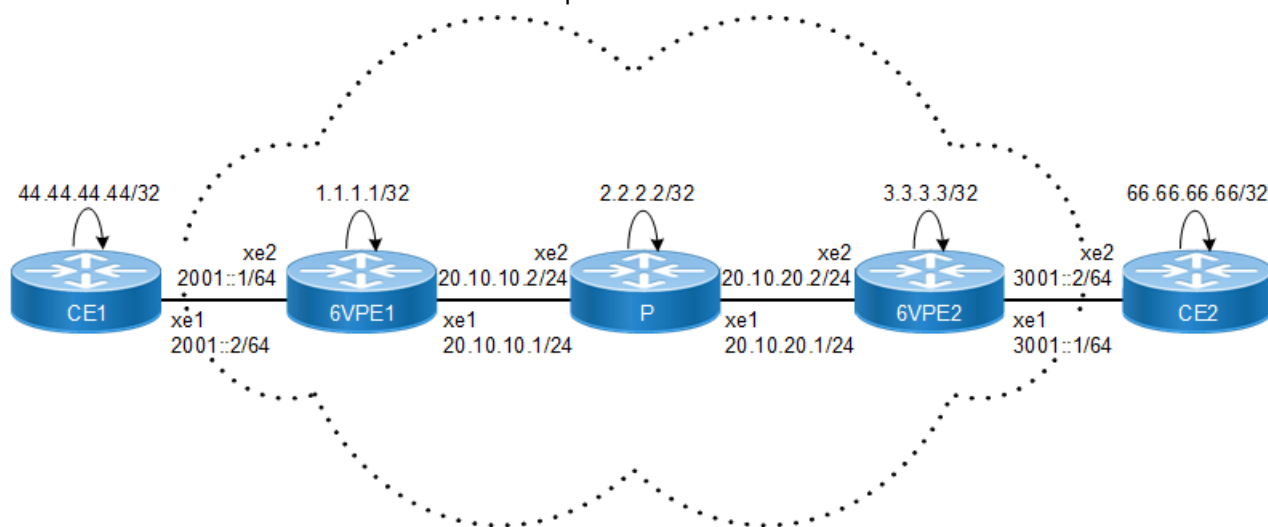


Figure 2-11: 6VPE Configuration

Configuration

CE1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 44.44.44.44/32 secondary	Assign the IPv4 address
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter interface mode.
(config-if)#ipv6 address 2001::2/64	Assign the IPv6 address.
(config-if)#exit	Exit interface mode.
(config)#ipv6 route 2ffe::/64 xe1	Advertise IPv6 static route.
(config)#router bgp 200	Enter BGP router mode.

(config-router)#bgp router-id 44.44.44.44	Configure bgp router-id
(config-router)#neighbor 2001::1 remote-as 100	Configure 6VPE1 as an eBGP4+ neighbor.
(config-router)#address-family ipv6 unicast	Enter address-family IPv6 unicast mode.
(config-router-af)#neighbor 2001::1 activate	Activate the neighbor in the IPv6 address family.
(config-router-af)#redistribute connected	Redistribute the connected route under address family IPv6 unicast.
(config-router-af)#redistribute static	Redistribute static routes.
(config-router-af)#commit	Commit the transaction.

CE2

#configure terminal	Enter configure mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 66.66.66.66/32 secondary	Assign the IPv4 address
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter interface mode.
(config-if)#ipv6 address 3001::2/64	Assign the IPv6 address.
(config-if)#exit	Exit interface mode.
(config)#ipv6 route 3ffe::/64 xe1	Configure IPV6 static route
(config)#router bgp 300	Enter BGP router mode.
(config-router)#bgp router-id 66.66.66.66	Configure BGP router-id
(config-router)#neighbor 3001::1 remote-as 100	Configure 6VPE1 as an eBGP4+ neighbor.
(config-router)#address-family ipv6 unicast	Enter address-family IPv6 unicast mode.
(config-router-af)#neighbor 3001::1 activate	Activate the neighbor in the IPv6 address family.
(config-router-af)#redistribute connected	Redistribute the connected route under address family IPv6 unicast.
(config-router-af)#redistribute static	Redistribute static routes.
(config-router-af)#commit	Commit the transaction.

PE1

#configure terminal	Enter configure mode.
(config)#ip vrf IPI	Create a new VRF named IPI.
(config-vrf)#rd 1:100	Assign the route distinguisher (RD) value as 1:100.
(config-vrf)#route-target both 100:200	Import routes between route target (RT) ext-communities 100 and 200.
(config-vrf)#router-id 77.77.77.77	Configure router-id for VRF
(config-vrf)#exit	Exit VRF mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip vrf forwarding IPI	Bind the interface connected to the CE router with VRF IPI.
(config-if)#ipv6 address 2001::1/64	Assign the IPv6 address.

(config-if)#exit	Exit interface mode.
(config)#router bgp 100	Enter BGP router mode.
(config-router)#bgp router-id 1.1.1.1	Configure BGP router-id
(config-router)#neighbor 3.3.3.3 remote-as 100	Configure 6VPE2 as an iBGP peer.
(config-router)#neighbor 3.3.3.3 update-source lo	Update the source as loopback for iBGP peering with the remote 6VPE router.
(config-router)#address-family ipv4 unicast	Enter address family mode
(config-router-af)#neighbor 3.3.3.3 activate	Activate the neighbor
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#address-family vpnv6 unicast	Enter VPNv6 address family mode.
(config-router-af)#neighbor 3.3.3.3 activate	Activate the 6VPE neighbor so that it can accept VPN IPv6 routes.
(config-router-af)#exit-address-family	Exit VPNv6 address family mode.
(config-router)#address-family ipv6 vrf IPI	Enter the IPv6 address family for VRF IPI.
(config-router-af)#neighbor 2001::2 remote-as 200	Activate CE inside IPv6 address family for vrf IPI.
(config-router-af)#neighbor 2001::2 activate	Activate the 6VPE neighbor so that it can accept VPN IPv6 routes.
(config-router-af)#redistribute connected	Redistribute the connected route under address family IPv6 for VRF IPI.
(config-router-af)#exit-address-family	Exit IPv6 Address Family mode.
(config-router)#exit	Exit router mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 1.1.1.1/32 secondary	Assign the IP address to loopback interface.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1
(config-router)#transport-address ipv4 1.1.1.1	Configure transport address as loopback address.
(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router LDP mode.
(config)#router rsvp	Enter RSVP router mode.
(config-router)#exit	Exit router mode.
(config)#interface xe2	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-rsvp	Enable RSVP in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#ip address 20.10.10.1/24	Assign IP address to interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Enter OSPF router mode.
(config-router)#ospf router-id 1.1.1.1	Configure OSPF router id same as loopback ip address.
(config-router)#network 1.1.1.1/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 20.10.10.1/24 area 0	

(config-router)#exit	Exit OSPF router mode.
(config)#rsvp-trunk toPE2	Enter the trunk mode for RSVP.
(config-trunk)#to 3.3.3.3	Specify IPv4 Egress for the LSP.
(config-trunk)#commit	Commit the transaction.

P1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Assign the IP address to loopback interface.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2
(config-router)#transport-address ipv4 2.2.2.2	Configure transport address as loopback address.
(config-router)#exit	Exit router mode.
(config)#router rsvp	Enter RSVP router mode.
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-rsvp	Enable RSVP in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#ip address 20.10.10.2/24	Assign IP address to interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-rsvp	Enable RSVP in interface.
(config-if)#enable-ldp ipv4	Enable ldp in interface.
(config-if)#ip address 20.10.20.1/24	Assign IP address to interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Enter OSPF router mode.
(config-router)#ospf router-id 2.2.2.2	Configure OSPF router id same as loopback ip address.
(config-router)#network 2.2.2.2/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 20.10.20.1/24 area 0	
(config-router)#network 20.10.10.2/24 area 0	
(config-router)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#ip vrf IPI	Create a new VRF named IPI.
(config-vrf)#rd 1:101	Assign the route distinguisher (RD) value as 1:101.

(config-vrf)#route-target both 100:200	Import routes between route target (RT) ext-communities 100 and 200.
(config-vrf)#router-id 55.55.55.55	Configure Router-id for VRF
(config-vrf)#exit	Exit VRF mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip vrf forwarding IPI	Bind the interface connected to the CE router with VRF IPI.
(config-if)#ipv6 address 3001::1/64	Assign the IPv6 address.
(config-if)#exit	Exit interface mode.
(config)#router bgp 100	Enter BGP router mode.
(config-router)#bgp router-id 3.3.3.3	Configure BGP router-id
(config-router)#neighbor 1.1.1.1 remote-as 100	Configure 6VPE2 as an iBGP peer.
(config-router)#neighbor 1.1.1.1 update-source lo	Update the source as loopback for iBGP peering with the remote 6VPE router.
(config-router)#address-family ipv4 unicast	Enter address family mode
(config-router-af)#neighbor 1.1.1.1 activate	Activate the neighbor
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#address-family vpnv6 unicast	Enter VPNv6 address family mode.
(config-router-af)#neighbor 1.1.1.1 activate	Activate the 6VPE neighbor so that it can accept VPN IPv6 routes.
(config-router-af)#exit-address-family	Exit VPNv6 address family mode.
(config-router)#address-family ipv6 vrf IPI	Enter the IPv6 address family for VRF IPI.
(config-router-af)#neighbor 3001::2 remote-as 300	Activate CE inside IPv6 address family for vrf IPI.
(config-router-af)#neighbor 3001::2 activate	Activate the neighbor
(config-router-af)#redistribute connected	Redistribute the connected route under address family IPv6 for VRF IPI.
(config-router-af)#exit-address-family	Exit IPv6 Address Family mode.
(config-router)#exit	Exit router mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 3.3.3.3/32 secondary	Assign the IP address to loopback interface.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 3.3.3.3	Set the router ID to IP address 3.3.3.3
(config-router)#transport-address ipv4 3.3.3.3	Configure transport address as loopback address.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#router rsvp	Enter RSVP router mode.
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface

(config-if)#enable-rsvp	Enable RSVP in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#ip address 20.10.20.2/24	Assign IP address to interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Enter OSPF router mode.
(config-router)#ospf router-id 3.3.3.3	Configure OSPF router id same as loopback ip address.
(config-router)#network 3.3.3.3/32 area 0 (config-router)#network 20.10.20.2/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#rsvp-trunk toPE1	Enter the trunk mode for RSVP.
(config-trunk)#to 1.1.1.1	Specify IPv4 Egress for the LSP.
(config-trunk)#commit	Commit the transaction.

Validation

CE1

CE1#show ipv6 route

IPv6 Routing Table

Codes: K - kernel route, C - connected, S - static, D- DHCP, R - RIP,
 O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
 E2 - OSPF external type 2, E - EVPN N1 - OSPF NSSA external type 1,
 N2 - OSPF NSSA external type 2, i - IS-IS, B - BGP,
 v - vrf leaked

Timers: Uptime

IP Route Table for VRF "default"

```

C      ::1/128 via ::, lo, 01:38:28
C      2001::/64 via ::, xe1, 01:20:30
S      2ffe::/64 [1/0] via ::, xe1, 00:01:27
B      3001::/64 [20/0] via fe80::5054:ff:fe29:189d, xe1, 00:06:40
B      3ffe::/64 [20/0] via fe80::5054:ff:fe29:189d, xe1, 00:02:24
C      fe80::/64 via ::, xe3, 01:38:28

```

CE1#show ipv6 bgp summary vrf all

BGP router identifier 44.44.44.44, local AS number 200

BGP table version is 4

3 BGP AS-PATH entries

0 BGP community entries

Neighbor PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
2001::1 3	4	100	1167	1522	4	0	0	00:13:23	

Total number of neighbors 1

Total number of Established sessions 1

PE1

PE1#show ipv6 route vrf IPI

IPv6 Routing Table

Codes: K - kernel route, C - connected, S - static, D- DHCP, R - RIP,
O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
E2 - OSPF external type 2, E - EVPN N1 - OSPF NSSA external type 1,
N2 - OSPF NSSA external type 2, i - IS-IS, B - BGP,
v - vrf leaked

Timers: Uptime

IP Route Table for VRF "IPI"

```
C      2001::/64 via ::, xe1, 01:12:03
B      2ffe::/64 [20/0] via fe80::5054:ff:fe60:f4e5, xe1, 00:02:05
B      3001::/64 [200/0] via ::ffff:3.3.3.3, 00:08:02
B      3ffe::/64 [200/0] via ::ffff:3.3.3.3, 00:03:33
C      fe80::/64 via ::, xe1, 01:12:32
```

PE1#show ip bgp summary vrf all

BGP router identifier 3.3.3.3, local AS number 100

BGP table version is 1

3 BGP AS-PATH entries

0 BGP community entries

Neighbor PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
1.1.1.1	4	100	78	84	1	0	0	00:32:15	0

Total number of neighbors 1

Total number of Established sessions 1

PE1#show ipv6 bgp summary vrf all

BGP router identifier 55.55.55.55, local AS number 100

BGP VRF IPI Route Distinguisher: 1:101

BGP table version is 1

3 BGP AS-PATH entries

0 BGP community entries

Neighbor PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
3001::2	4	200	79	81	1	0	0	00:32:15	

Total number of neighbors 1

Total number of Established sessions 1

PE1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nextthop					
L>	2.2.2.2/32	1	1	-	-	LSP_DEFAULT	3
xe2	No	20.10.10.2					
R(t)>	3.3.3.3/32	4	4	5001	Yes	LSP_DEFAULT	24320
xe2	No	20.10.10.2					
L	3.3.3.3/32	3	2	-	-	LSP_DEFAULT	24960
xe2	No	20.10.10.2					
L>	20.10.20.0/24	2	1	-	-	LSP_DEFAULT	3
xe2	No	20.10.10.2					

PE1#show rsvp session

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass

State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary

* indicates the session is active with local repair at one or more nodes

(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:

To	From	Type	LSPName	State	Uptime	Rt
Style	Labelin	Labelout	DSType			
3.3.3.3	1.1.1.1	PRI	toPE2-Primary	UP	00:08:44	
1 1 SE	-	24320	DEFAULT			

Total 1 displayed, Up 1, Down 0.

Egress RSVP:

To	From	Type	LSPName	State	Uptime	Rt
Style	Labelin	Labelout	DSType			
1.1.1.1	3.3.3.3	PRI	toPE1-Primary	UP	00:08:39	
1 1 SE	24960	-	ELSP_CON			

Total 1 displayed, Up 1, Down 0.

PE1#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM

K - CLI ILM, T - MPLS-TP, s - Stitched ILM

S - SNMP, L - LDP, R - RSVP, C - CRLDP

B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT

O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI

P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nextthop		LSP-Type				
B>	IPI	2	25600	Nolabel	N/A	IPI
A		LSP_DEFAULT				
LT						
R>	3.3.3.3/32	2	24320	Nolabel	N/A	N/A
127.0.0.1		ELSP_CONF				
IG						

```
PE1#show mpls vrf-table
```

```
Output for IPv6 VRF table with id: 2
```

```
Primary FTN entry with FEC: 3001::/64, id: 1, row status: Active, Tunnel-Policy: N/A  
Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming  
DSCP: none
```

```
Transport Tunnel id: 5001, Protected LSP id: 2201, QoS Resource id: 0, Description: N/A,  
Color: 0
```

```
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
```

```
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
```

```
Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
Out-segment with ix: 5, owner: BGP, Stale: NO, BGP out intf: xe2, transport out  
intf: xe2, out label: 24320
```

```
Nexthop addr: 3.3.3.3          cross connect ix: 5, op code: Push and Lookup
```

```
Primary FTN entry with FEC: 3ffe::/64, id: 2, row status: Active, Tunnel-Policy: N/A  
Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming  
DSCP: none
```

```
Transport Tunnel id: 5001, Protected LSP id: 2201, QoS Resource id: 0, Description: N/A,  
Color: 0
```

```
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
```

```
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
```

```
Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
Out-segment with ix: 5, owner: BGP, Stale: NO, BGP out intf: xe2, transport out  
intf: xe2, out label: 24320
```

```
Nexthop addr: 3.3.3.3          cross connect ix: 5, op code: Push and Lookup
```

```
PE1#show mpls ftn-table
```

```
Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A  
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:  
none
```

```
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
```

```
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
```

```
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
```

```
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3
```

```
Nexthop addr: 20.10.10.2       cross connect ix: 1, op code: Push
```

```
Primary FTN entry with FEC: 3.3.3.3/32, id: 4, row status: Active, Tunnel-Policy: N/A  
Owner: RSVP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming  
DSCP: none
```

```
Tunnel id: 5001, Protected LSP id: 2201, QoS Resource id: 2, Description: toPE2,  
Color: 0
```

```
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
```

```
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 4
```

```
Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
Out-segment with ix: 4, owner: RSVP, Stale: NO, out intf: xe2, out label: 24320
```

```
Nexthop addr: 20.10.10.2       cross connect ix: 4, op code: Push
```

```
Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
```

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2

Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Down

Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xe2, out label: 24960

Nexthop addr: 20.10.10.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 20.10.20.0/24, id: 2, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.10.10.2 cross connect ix: 1, op code: Push

PE1#show ip bgp vpnv6 all

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal, l - labeled

S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:100 (Default for VRF IPI)					
*> 1 2001::/64	::	0	100	32768	?
* 2001::/64	2001::2(fe80::5054:ff:fe60:f4e5)	0	100	0	200 ?
*> 1 2ffe::/64	2001::2(fe80::5054:ff:fe60:f4e5)	0	100	0	200 ?
*>i 3001::/64	::ffff:3.3.3.3	0	100	0	?
*>i 3ffe::/64	::ffff:3.3.3.3	0	100	0	300 ?
Announced routes count = 3					
Accepted routes count = 2					
Route Distinguisher: 1:101					
*>i 3001::/64	::ffff:3.3.3.3	0	100	0	?
*>i 3ffe::/64	::ffff:3.3.3.3	0	100	0	300 ?
Announced routes count = 0					
Accepted routes count = 2					

PE1#show ip bgp neighbors

BGP neighbor is 3.3.3.3, remote AS 100, local AS 100, internal link

BGP version 4, local router ID 1.1.1.1, remote router ID 3.3.3.3

BGP state = Established, up for 00:09:55

Last read 00:00:21, hold time is 90, keepalive interval is 30 seconds

Neighbor capabilities:

```
Route refresh: advertised and received (old and new)
Address family IPv4 Unicast: advertised and received
Address family VPNv6 Unicast: advertised and received
Received 27 messages, 0 notifications, 0 in queue
Sent 27 messages, 0 notifications, 0 in queue
Route refresh request: received 0, sent 0
Minimum time between advertisement runs is 5 seconds
Update source is lo
For address family: IPv4 Unicast
BGP table version 1, neighbor version 1
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (both)
0 accepted prefixes
0 announced prefixes

For address family: VPNv6 Unicast
BGP table version 3, neighbor version 3
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (both)
2 accepted prefixes
2 announced prefixes

Connections established 1; dropped 0
Local host: 1.1.1.1, Local port: 33537
Foreign host: 3.3.3.3, Foreign port: 179
Nexthop: 1.1.1.1
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

BGP neighbor is 2001::2, vrf IPI, remote AS 200, local AS 100, external link
BGP version 4, local router ID 77.77.77.77, remote router ID 44.44.44.44
BGP state = Established, up for 00:16:19
Last read 00:00:10, hold time is 90, keepalive interval is 30 seconds
Neighbor capabilities:
Route refresh: advertised and received (old and new)
Address family IPv6 Unicast: advertised and received
Received 42 messages, 0 notifications, 0 in queue
Sent 42 messages, 0 notifications, 0 in queue
Route refresh request: received 0, sent 0
Minimum time between advertisement runs is 30 seconds
For address family: IPv6 Unicast
BGP table version 1, neighbor version 1
Index 0, Offset 0, Mask 0x1
Community attribute sent to this neighbor (standard)
2 accepted prefixes
3 announced prefixes

Connections established 1; dropped 0
Local host: 2001::1, Local port: 34776
```

Foreign host: 2001::2, Foreign port: 179
 Nexthop: 77.77.77.77
 Nexthop global: 2001::1
 Nexthop local: fe80::5054:ff:fe29:189d
 BGP connection: shared network

P1

P1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-
Intf	Nexthop						
L>	1.1.1.1/32	1	0	Yes	LSP_DEFAULT	3	xe2
20.10.10.1							
L>	3.3.3.3/32	2	0	Yes	LSP_DEFAULT	3	xe1
20.10.20.2							

P1#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, S - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 U - unknown

Code	FEC/VRF	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf
Nexthop		LSP-Type				
R>	1.1.1.1/32	2	24321	24960	N/A	xe1
20.10.10.1		ELSP_CONFIG				
R>	3.3.3.3/32	1	24320	24960	N/A	xe2
20.10.20.2		ELSP_CONFIG				
L>	1.1.1.1/32	4	24961	3	N/A	xe1
20.10.10.1		LSP_DEFAULT				
L>	3.3.3.3/32	5	24960	3	N/A	xe2
20.10.20.2		LSP_DEFAULT				

P1#show ip ospf neighbor

Total number of full neighbors: 2

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	
Instance ID						
1.1.1.1	1	Full/Backup	00:00:31	20.10.10.1	xe1	0
3.3.3.3	1	Full/DR	00:00:32	20.10.20.2	xe2	0

PE2

PE2#show ipv6 route vrf IPI

IPv6 Routing Table

Codes: K - kernel route, C - connected, S - static, R - RIP, O - OSPF,

IA - OSPF inter area, E1 - OSPF external type 1,
 E2 - OSPF external type 2, E - EVPN N1 - OSPF NSSA external type 1,
 N2 - OSPF NSSA external type 2, I - IS-IS, B - BGP

Timers: Uptime

IP Route Table for VRF "IPI"

```
C      ::1/128 via ::, lo.IPI, 00:24:23
C      3001::/64 via ::, xe1, 00:24:22
B      3ffe::/64 [20/0] via fe80::3617:ebff:fe0e:1201, xe1, 00:05:28
C      fe80::/64 via ::, xe1, 00:24:22
```

PE2#show ip bgp summary vrf all

BGP router identifier 55.55.55.55, local AS number 100
 BGP VRF IPI Route Distinguisher: 1:100
 BGP table version is 1
 3 BGP AS-PATH entries
 0 BGP community entries

Neighbor PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
3001::2	4	300	116	181	1	0	0	00:22:05	
0									

Total number of neighbors 1

Total number of Established sessions 1

BGP router identifier 3.3.3.3, local AS number 100
 BGP table version is 1
 3 BGP AS-PATH entries
 0 BGP community entries

Neighbor PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
1.1.1.1	4	100	65	66	1	0	0	00:26:21	
0									

Total number of neighbors 1

Total number of Established sessions 1

PE2#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code Intf	FEC Nexthop	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-
R(t)> 20.10.20.1	1.1.1.1/32	1	5001	Yes	LSP_DEFAULT	24321	xe2
L 20.10.20.1	1.1.1.1/32	2	0	Yes	LSP_DEFAULT	24961	xe2

```

L> 2.2.2.2/32      3      0      Yes  LSP_DEFAULT  3      xe2
20.10.20.1
L> 20.10.10.0/24   4      0      Yes  LSP_DEFAULT  3      xe2
20.10.20.1

```

PE2#show rsvp session

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass

State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary

* indicates the session is active with local repair at one or more nodes

Ingress RSVP:

To Style	Labelin	From Labelout	Type DSType	LSPName	State	Uptime	Rt
1.1.1.1		3.3.3.3	PRI	toPE1-Primary	UP	00:23:21	1
1 SE	-	24321	DEFAULT				

Total 1 displayed, Up 1, Down 0.

Egress RSVP:

To Style	Labelin	From Labelout	Type DSType	LSPName	State	Uptime	Rt
3.3.3.3		1.1.1.1	PRI	toPE2-Primary	UP	00:23:33	1
1 SE	24960	-	ELSP_CON				

Total 1 displayed, Up 1, Down 0.

PE2#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, S - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 U - unknown

Code	FEC/VRF	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf
Nexthop		LSP-Type				
B>	3ffe::/64	3	24321	N/A	N/A	xe1
	fe80::3617:ebff:fe0e:1201	LSP_DEFAULT				
B>	3001::/64	2	24320	N/A	xe1	::
	LSP_DEFAULT					
R>	3.3.3.3/32	1	24960	N/A	N/A	N/A
	127.0.0.1	ELSP_CONFIG				

PE2#show ip bgp neighbors

BGP neighbor is 1.1.1.1, remote AS 100, local AS 100, internal link

BGP version 4, local router ID 3.3.3.3, remote router ID 1.1.1.1

BGP state = Established, up for 00:23:39

Last read 00:00:27, hold time is 90, keepalive interval is 30 seconds

Neighbor capabilities:

Route refresh: advertised and received (old and new)

Address family IPv4 Unicast: advertised and received

Address family VPNv6 Unicast: advertised and received

Received 58 messages, 0 notifications, 0 in queue

Sent 60 messages, 0 notifications, 0 in queue

```
Route refresh request: received 0, sent 0
Minimum time between advertisement runs is 5 seconds
Update source is lo
For address family: IPv4 Unicast
BGP table version 1, neighbor version 1
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (both)
0 accepted prefixes
0 announced prefixes

For address family: VPNv6 Unicast
BGP table version 4, neighbor version 4
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (both)
2 accepted prefixes
2 announced prefixes

Connections established 1; dropped 0
Local host: 3.3.3.3, Local port: 37145
Foreign host: 1.1.1.1, Foreign port: 179
Nexthop: 3.3.3.3
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

BGP neighbor is 3001::2, vrf IPI, remote AS 300, local AS 100, external link
BGP version 4, local router ID 55.55.55.55, remote router ID 66.66.66.66
BGP state = Established, up for 00:19:23
Last read 00:00:05, hold time is 90, keepalive interval is 30 seconds
Neighbor capabilities:
  Route refresh: advertised and received (old and new)
  Address family IPv4 Unicast: advertised and received
  Address family IPv6 Unicast: advertised and received
Received 110 messages, 0 notifications, 0 in queue
Sent 113 messages, 62 notifications, 0 in queue
Route refresh request: received 0, sent 0
Minimum time between advertisement runs is 30 seconds
For address family: IPv4 Unicast
BGP table version 1, neighbor version 1
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (standard)
0 accepted prefixes
0 announced prefixes

For address family: IPv6 Unicast
BGP table version 1, neighbor version 1
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (standard)
2 accepted prefixes
3 announced prefixes
```

```

Connections established 1; dropped 0
Local host: 3001::1, Local port: 179
Foreign host: 3001::2, Foreign port: 58741
Nexthop: 55.55.55.55
Nexthop global: 3001::1
Nexthop local: fe80::da9e:f3ff:fec9:65a1
BGP connection: shared network
Last Reset: 00:19:28, due to OPEN Message Error (Notification sent)
Notification Error Message: (OPEN Message Error/Bad BGP Identifier.)

```

```

PE2#show ip bgp vpnv6 all
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, l -
labeled
                S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

```

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:100 (Default for VRF IPI)					
*>i 2001::/64	::ffff:101:101		0	100	0
? 200 ?					
*>i 2ffe::/64	::ffff:101:101		0	100	0
*> 1 3001::/64	::	0	100	32768	?
* 3001::/64	3001::2(fe80::3617:ebff:fe0e:1201)	0	100	0	300 ?
*> 1 3ffe::/64	3001::2(fe80::3617:ebff:fe0e:1201)	0	100	0	300 ?
Announced routes count = 3					
Accepted routes count = 2					
Route Distinguisher: 1:100					
*>i 2001::/64	::ffff:101:101		0	100	0
? 200 ?					
*>i 2ffe::/64	::ffff:101:101		0	100	0
Announced routes count = 0					
Accepted routes count = 2					

```

PE2#show mpls ftn-table
Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active
Owner: RSVP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming
DSCP: none
Tunnel id: 5001, Protected LSP id: 2201, QoS Resource id: 2, Description: toPE1
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: RSVP, out intf: xe1, out label: 24321
Nexthop addr: 20.10.20.1 cross connect ix: 4, op code: Push

```

```

Primary FTN entry with FEC: 1.1.1.1/32, id: 2, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

```

```
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Down
Out-segment with ix: 4, owner: LDP, out intf: xe1, out label: 24961
Nexthop addr: 20.10.20.1 cross connect ix: 5, op code: Push
```

```
Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
```

```
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: LDP, out intf: xe1, out label: 3
Nexthop addr: 20.10.20.1 cross connect ix: 6, op code: Push
```

```
Primary FTN entry with FEC: 20.10.10.0/24, id: 4, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
```

```
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: LDP, out intf: xe1, out label: 3
Nexthop addr: 20.10.20.1 cross connect ix: 6, op code: Push
```

```
PE2#show mpls vrf-table
```

```
Output for IPv6 VRF table with id: 2
```

```
Primary FTN entry with FEC: 2001::/64, id: 1, row status: Active
Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming
DSCP: none
```

```
Tunnel id: 5001, Protected LSP id: 2201, QoS Resource id: 0, Description: N/A
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: BGP, out intf: N/A, out label: 24320
Nexthop addr: 1.1.1.1 cross connect ix: 3, op code: Push and Lookup
```

```
Primary FTN entry with FEC: 2ffe::/64, id: 2, row status: Active
Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming
DSCP: none
```

```
Tunnel id: 5001, Protected LSP id: 2201, QoS Resource id: 0, Description: N/A
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 6
Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: BGP, out intf: N/A, out label: 24321
Nexthop addr: 1.1.1.1 cross connect ix: 7, op code: Push and Lookup
```

CE2

```
CE2#show ipv6 route
```

```
IPv6 Routing Table
```

Codes: K - kernel route, C - connected, S - static, R - RIP, O - OSPF,
IA - OSPF inter area, E1 - OSPF external type 1,
E2 - OSPF external type 2, E - EVPN N1 - OSPF NSSA external type 1,
N2 - OSPF NSSA external type 2, I - IS-IS, B - BGP

Timers: Uptime

IP Route Table for VRF "default"

```
C      ::1/128 via ::, lo, 00:37:26
B      2001::/64 [20/0] via fe80::da9e:f3ff:fec9:65a1, xe2, 00:20:44
B      2ffe::/64 [20/0] via fe80::da9e:f3ff:fec9:65a1, xe2, 00:09:52
C      3001::/64 via ::, xe2, 00:27:07
S      3ffe::/64 [1/0] via ::, xe2, 00:07:31
C      fe80::/64 via ::, xe2, 00:37:26
```

CE2#show ip bgp summary vrf all

BGP router identifier 66.66.66.66, local AS number 300

BGP table version is 1

3 BGP AS-PATH entries

0 BGP community entries

Neighbor PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
3001::1	4	100	178	176	1	0	0	00:20:51	
0									

Total number of neighbors 1

Total number of Established sessions 1

Multi-Protocol Label Switching Configuration

CHAPTER 1 Understanding Label Space

This chapter contains configurations for Label Space. It also provides an overview of Label Space concepts.

Overview

The Label space refers to the scope of labels in a given LSR. It determines assignment and distribution of labels to a given peer. During data flow, it decides the key for looking up MPLS table and takes appropriate action based on the entry.

OcNOS supports *per-platform* label space, where a label must be unique for the entire platform. A label is interpreted the same way at all the interfaces. The FIB entry in the router does not contain incoming interface-related information. Thus the incoming traffic will be matched only with the label.

Topology

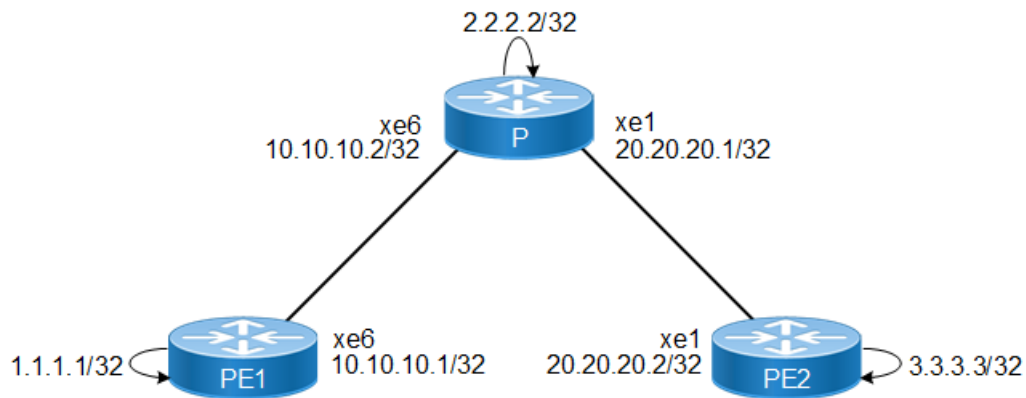


Figure 1-12: LDP Topology

PE1

PE1#configure terminal	Enter configure mode
PE1(config)#interface lo	Enter interface mode.
PE1(config-if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback address
PE1(config-if)#exit	Exit interface mode
PE1(config)#interface xe6	Specify the interface (xe6) to be configured
PE1(config-if)#ip address 10.10.10.1/24	Configure IP address for the interface
PE1(config-if)#no shutdown	Administratively bringing up the interface
PE1(config-if)#exit	Exit interface mode
PE1(config)#router ospf 100	Configure the routing process and specify the Process ID (100)
PE1(config-router)#ospf router-id 1.1.1.1	Configure OSPF router ID same as loopback IP address
PE1(config-router)#network 10.10.10.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
PE1(config-router)#network 1.1.1.1/32 area 0	

PE1(config-router)#exit	Exit configure mode
PE1(config)#router ldp	Enter router mode for LDP
PE1(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1
PE1(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
PE1(config-router)# targeted-peer ipv4 3.3.3.3	Configure targeted peer.
PE1(config-router-targeted-peer)#exit	Exit from router target peer and LDP mode
PE1(config-if)#exit	Exit interface mode
PE1(config)#interface xe6	Specify the interface (xe6)to be configured
PE1(config-if)#label-switching	Enabling label switching capability on router
PE1(config-if)#enable-ldp ipv4	Enabling ldp on interface
PE1(config-if)#commit	Commit the transaction.

P

P#configure terminal	Enter configure mode.
P(config)#interface lo	Enter interface mode.
P(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback address
P(config-if)#exit	Exit interface mode
P(config)#interface xe6	Specify the interface (xe6) to be configured
P(config-if)#ip address 10.10.10.2/24	Configure IP address for the interface
P(config-if)#no shutdown	Administratively bringing up the interface
P(config)#interface xe1	Specify the interface (xe1) to be configured
P(config-if)#ip address 20.20.20.1/24	Configure IP address for the interface
P(config)#router ospf 100	Configure the routing process and specify the Process ID (100)
P(config-router)#ospf router-id 2.2.2.2	Configure OSPF router ID same as loopback IP address
P(config-router)#network 10.10.10.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
P(config-router)#network 20.20.20.0/24 area 0	
P(config-router)#network 2.2.2.2/32 area 0	
P(config-router)#exit	Exit router mode
P(config)#router ldp	Enter router mode for LDP
P(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2
P(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
P(config-router)#exit	Exit router mode for LDP

P(config)#mpls min-label-value 1000 max-label-value 50000 label-space 0	Configure the minimum label value and maximum label value to be used by Platform label space (Label space 0)
P(config)#interface xe6	Specify the interface (xe6) to be configured
P(config-if)#label-switching	Enabling label switching capability on router
P(config-if)#enable-ldp ipv4	Enabling ldp on interface
P(config-if)#exit	Exit interface mode
P(config)#interface xe1	Specify the interface (xe1) to be configured
P(config-if)#label-switching	Enabling label switching capability on router
P(config-if)#enable-ldp ipv4	Enabling ldp on interface
P(config-if)#commit	Commit the transaction.

PE2

PE2#configure terminal	Enter configure mode.
PE2(config)#interface lo	Enter interface mode.
PE2(config-if)#ip address 3.3.3.3/32 secondary	Configure IP address for the loopback address
PE2(config-if)#exit	Exit interface mode
PE2(config)#interface xe1	Specify the interface (xe1) to be configured
PE2(config-if)#ip address 20.20.20.2/24	Configure IP address for the interface
PE2(config-if)#no shutdown	Administratively bringing up the interface
PE2(config-if)#exit	Exit interface mode
PE2(config)#router ospf 100	Configure the routing process and specify the Process ID (100)
PE2(config-router)#ospf router-id 3.3.3.3	Configure OSPF router ID same as loopback IP address
PE2(config-router)#network 20.20.20.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
PE2(config-router)#network 3.3.3.3/32 area 0	
PE2(config-router)#exit	Exit router mode
PE2(config)#router ldp	Enter router mode for LDP
PE2(config-router)#router-id 3.3.3.3	Set the router ID to IP address 3.3.3.3
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
PE2(config-router)# targeted-peer ipv4 1.1.1.1	Configure targeted peer.
PE1(config-router-targeted-peer)#exit	Exit from router target peer and LDP mode
PE2(config-router)#exit	Exit router mode for LDP
PE2(config)#interface xe1	Specify the interface (xe1) to be configured
PE2(config-if)#label-switching	Enabling label switching capability on router
PE2(config-if)#enable-ldp ipv4	Enabling ldp on interface
PE2(config-if)#commit	Commit the transaction.

Validation

```

PE1#show ldp
Router ID           : 1.1.1.1
LDP Version         : 1
Fast-reroute Per-prefix : Disabled
Global Merge Capability : Merge Capable
Label Advertisement Mode : Downstream Unsolicited
Label Retention Mode  : Liberal
Label Control Mode     : Independent
Instance Loop Detection : Off
Request Retry          : Off
Propagate Release      : Disabled
Graceful Restart       : Disabled
Hello Interval         : 5
Targeted Hello Interval : 15
Hold time              : 15
Targeted Hold time     : 45
Keepalive Interval     : 10
Keepalive Timeout      : 30
Request retry Timeout   : 5
Auto Targeted Hello Receipt : Disabled
Transport Address data :
  Labelspace 0         : 1.1.1.1 (in use)
Import BGP routes      : No

```

```
PE1#show ip ospf neighbor
```

```
Total number of full neighbors: 1
```

```
OSPF process 100 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	
Instance ID						
2.2.2.2	1	Full/Backup	00:00:30	10.10.10.2	xe1	0

```

P#show ldp
Router ID           : 2.2.2.2
LDP Version         : 1
Global Merge Capability : Merge Capable
Label Advertisement Mode : Downstream Unsolicited
Label Retention Mode  : Liberal
Label Control Mode     : Independent
Instance Loop Detection : Off
Request Retry          : Off
Propagate Release      : Disabled
Graceful Restart       : Disabled
Hello Interval         : 5
Targeted Hello Interval : 15
Hold time              : 15
Targeted Hold time     : 45

```



```

Keepalive Interval      : 10
Keepalive Timeout       : 30
Request retry Timeout   : 5
Auto Targeted Hello Receipt: Disabled
Transport Address data  :
  Labelspace 0          : 2.2.2.2 (in use)
Import BGP routes       : No

```

```
P#show mpls label-space 0
```

```

Label range (min - max)      : 1000 - 50000

module-static
  Default range              : 1000 - 3839

module-srgb
  Default range (Usable)     : 3840 - 8739
  Default range (Allotted)   : 3840 - 8959

module-srlb
  Default range (Usable)     : 8960 - 9959
  Default range (Allotted)   : 8960 - 10239

module-rsvp
  Configured range           : N/A
  Current dynamic range      : N/A

module-ldp
  Configured range           : Not configured
  Current dynamic range      : 10880 - 11519

module-ldp-vc
  Configured range           : Not configured
  Current dynamic range      : 11520 - 12159

module-bgp
  Configured range           : N/A
  Current dynamic range      : N/A

```

```
P#show ip ospf neighbor
```

```
Total number of full neighbors: 2
```

```
OSPF process 100 VRF(default):
```

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
10.12.49.142	1	Full/DR	00:00:34	10.10.10.1	xe1	0
10.12.49.158	1	Full/Backup	00:00:36	20.20.20.2	xe6	0

```
P#show mpls ilm-table
```

```

Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
       K - CLI ILM, T - MPLS-TP, s - Stitched ILM

```

S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nexthop		pri	LSP-Type			
L> 1.1.1.1/32		2	10881	3	N/A	eth3
10.10.10.1		Yes	LSP_DEFAULT			
L> 3.3.3.3/32		1	10880	3	N/A	eth2
20.20.20.2		Yes	LSP_DEFAULT			

```

PE2#show ldp
Router ID           : 3.3.3.3
LDP Version         : 1
Fast-reroute Per-prefix : Disabled
Global Merge Capability : Merge Capable
Label Advertisement Mode : Downstream Unsolicited
Label Retention Mode   : Liberal
Label Control Mode     : Independent
Instance Loop Detection : Off
Request Retry          : Off
Propagate Release      : Disabled
Graceful Restart       : Disabled
Hello Interval         : 5
Targeted Hello Interval : 15
Hold time              : 15
Targeted Hold time     : 45
Keepalive Interval     : 10
Keepalive Timeout      : 30
Request retry Timeout   : 5
Auto Targeted Hello Receipt : Disabled
Transport Address data :
  Labelspace 0         : 3.3.3.3 (in use)
Import BGP routes      : No
  
```

```

PE2#show ip ospf neighbor
  
```

```

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID      Pri   State           Dead Time   Address      Interface
Instance ID
2.2.2.2          1   Full/Backup     00:00:29   20.20.20.1   xe1          0
  
```

CHAPTER 2 Understanding MPLS TTL Processing

This chapter contains configurations for MPLS-TTL-Processing. It also provides an overview of MPLS-TTL-Processing concepts.

Overview

This feature performs 'Time To Live' (TTL) processing for Multi-Protocol Label Switching (MPLS) packets. The TTL processing is decided by the model chosen by you. This feature provides TTL processing of MPLS packets on ingress, egress, and intermediate routers. TTL processing is compliant with RFC 3443.

The details of TTL processing vary with the tunnel model that is configured for TTL processing. The incoming and outgoing TTL of the packet is determined by the configured tunnel model. Two Models are supported, pipe model and uniform model. Pipe model is default, where MPLS header TTL Value won't get propagated to IP header.

While pipe mode is the default, you can choose the uniform model with the `mpls lsp-model uniform` command.

For more about the uniform model and pipe models, see [MPLS DiffServ Configuration](#).

Topology

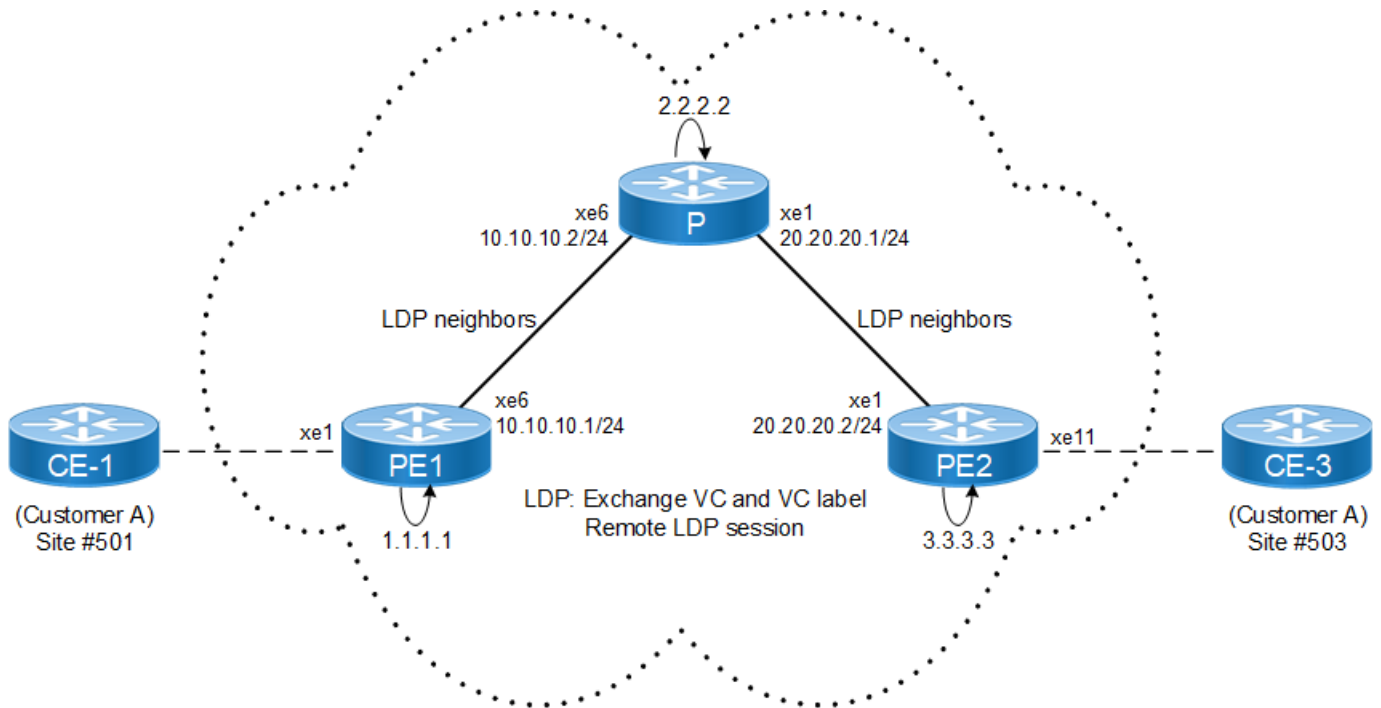


Figure 2-13: TTL Processing Topology

Configuration

PE1

PE1#configure terminal	Enter configure mode
PE1(config)#interface lo	Enter interface mode.
PE1(config-if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback address
PE1(config-if)#exit	Exit interface mode
PE1(config)#interface xe6	Specify the interface (xe6) to be configured
PE1(config-if)#ip address 10.10.10.1/24	Configure IP address for the interface
PE1(config-if)#no shutdown	Administratively bringing up the interface
PE1(config-if)#exit	Exit interface mode
PE1(config)#router ospf 100	Configure the routing process and specify the Process ID (100)
PE1(config-router)#ospf router-id 1.1.1.1	Configure ospf router id same as loopback ip address.
PE1(config-router)#network 10.10.10.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
PE1(config-router)#network 1.1.1.1/32 area 0	
PE1(config-router)#exit	Exit configure mode
PE1(config)#router ldp	Enter router mode for LDP
PE1(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1
PE1(config-router)#transport-address ipv4 1.1.1.1 0	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
PE1(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted peer.
PE1(config-router)#exit	Exit router mode for LDP
PE1(config)#interface xe6	Specify the interface (xe6) to be configured
PE1(config-if)#label-switching	Enabling label switching capability on router
PE1(config-if)#enable-ldp ipv4	Enabling ldp on interface
PE1(config-if)#commit	Commit the transaction

P

P#configure terminal	Enter configure mode.
P(config)#interface lo	Enter interface mode.
P(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback address
P(config-if)#exit	Exit interface mode
P(config)#interface xe6	Specify the interface (xe6) to be configured
P(config-if)#ip address 10.10.10.2/24	Configure IP address for the interface
P(config-if)#no shutdown	Administratively bringing up the interface
P(config)#interface xe1	Specify the interface (xe1) to be configured

P(config-if)#ip address 20.20.20.1/24	Configure IP address for the interface
P(config)#router ospf 100	Configure the routing process and specify the Process ID (100)
P(config-router)#ospf router-id 2.2.2.2	Configure OSPF router id same as loopback IP address.
P(config-router)#network 10.10.10.0/24 area 0 P(config-router)#network 20.20.20.0/24 area 0 P(config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
P(config-router)#exit	Exit router mode
P(config)#router ldp	Enter router mode for LDP
P(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2
P(config-router)#transport-address ipv4 2.2.2.2 0	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note:It is preferable to use the loopback address as the transport address.
P(config-router)#exit	Exit router mode for LDP
P(config)#interface xe6	Specify the interface (xe6)to be configured
P(config-if)#label-switching	Enabling label switching capability on router
P(config-if)#enable-ldp ipv4	Enabling ldp on interface
P(config)#interface xe1	Specify the interface (xe1)to be configured
P(config-if)#label-switching	Enabling label switching capability on router
P(config-if)#enable-ldp ipv4	Enabling ldp on interface
P(config-if)#commit	Commit the transaction

PE2

PE2#configure terminal	Enter configure mode.
PE2(config)#interface lo	Enter interface mode.
PE2(config-if)#ip address 3.3.3.3/32 secondary	Configure IP address for the loopback address
PE2(config-if)#exit	Exit interface mode
PE2(config)#interface xe1	Specify the interface (xe1) to be configured
PE2(config-if)#ip address 20.20.20.2/24	Configure IP address for the interface
PE2(config-if)#no shutdown	Administratively bringing up the interface
PE2(config-if)#exit	Exit interface mode
PE2(config)#router ospf 100	Configure the routing process and specify the Process ID (100)
PE2(config-router)#ospf router-id 3.3.3.3	Configure OSPF router ID same as loopback IP address.
PE2(config-router)#network 20.20.20.0/24 area 0 PE2(config-router)#network 3.3.3.3/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
PE2(config)#router ldp	Enter router mode for LDP
PE2(config-router)#router-id 3.3.3.3	Set the router ID to IP address 3.3.3.3

PE2(config-router)#transport-address ipv4 3.3.3.3 0	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
PE2(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
PE2 (config-router-targeted-peer)#exit	Exit-targeted-peer-mode
PE2(config-router)#exit	Exit router mode for LDP
PE2(config)#interface xe1	Specify the interface (xe1)to be configured
PE2(config-if)#label-switching	Enabling label switching capability on router
PE2(config-if)#enable-ldp ipv4	Enabling ldp on interface
PE2(config-if)#commit	Commit the transaction

Validation

PE1#show ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
2.2.2.2	1	Full/DR	00:00:31	10.10.10.2	xe6	0

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
3.3.3.3	xe6	Passive	OPERATIONAL	30	00:03:03
2.2.2.2	xe6	Passive	OPERATIONAL	30	00:03:46

P#show ip ospf neighbor

Total number of full neighbors: 2

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
1.1.1.1 0	1	Full/Backup	00:00:37	10.10.10.1	xe6	
3.3.3.3	1	Full/DR	00:00:34	20.20.20.2	xe1	0

P#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
3.3.3.3	xe1	Passive	OPERATIONAL	30	00:06:21
1.1.1.1	xe6	Active	OPERATIONAL	30	00:06:39

PE2#show ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
2.2.2.2	1	Full/Backup	00:00:37	20.20.20.1	xe1	0

PE2#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:06:07
2.2.2.2	xe1	Active	OPERATIONAL	30	00:06:33

PE1#ping 3.3.3.3

Press CTRL+C to exit

PING 3.3.3.3 (3.3.3.3) 56(84) bytes of data.

64 bytes from 3.3.3.3: icmp_seq=1 ttl=63 time=2.17 ms

64 bytes from 3.3.3.3: icmp_seq=2 ttl=63 time=2.26 ms

64 bytes from 3.3.3.3: icmp_seq=3 ttl=63 time=2.11 ms

64 bytes from 3.3.3.3: icmp_seq=4 ttl=63 time=1.91 ms

--- 3.3.3.3 ping statistics ---

4 packets transmitted, 4 received, 0% packet loss, time 8ms

rtt min/avg/max/mdev = 1.912/2.112/2.261/0.127 ms

PE1#traceroute 2.2.2.2

traceroute to 2.2.2.2 (2.2.2.2), 30 hops max, 60 byte packets

1 2.2.2.2 (2.2.2.2) 1.172 ms 0.918 ms 0.983 ms

PE1#traceroute 3.3.3.3

traceroute to 3.3.3.3 (3.3.3.3), 30 hops max, 60 byte packets

1 * * *

2 3.3.3.3 (3.3.3.3) 5.440 ms 5.215 ms 5.305 ms

CHAPTER 3 MPLS Layer-3 VPN Configurations

This chapter contains configurations for MPLS Layer-3 Virtual Private Networks (VPNs).

Overview

The MPLS Layer-3 VPN solution provides address space and routing separation via the use of per-VPN Routing and Forwarding tables (VRFs), and MPLS switching in the core and at the edge of the network. VPN customer routing data is imported into the VRFs utilizing the Route Target BGP extended community. This routing data is identified by a Route Distinguisher (RD) and is distributed among Provider Edge (PE) routers using Multi-Protocol BGP extensions.

Terminology

The following illustrates a Virtual Private Network in a CConnect Service Provider Network. This illustration corresponds to the terms defined in this subsection.

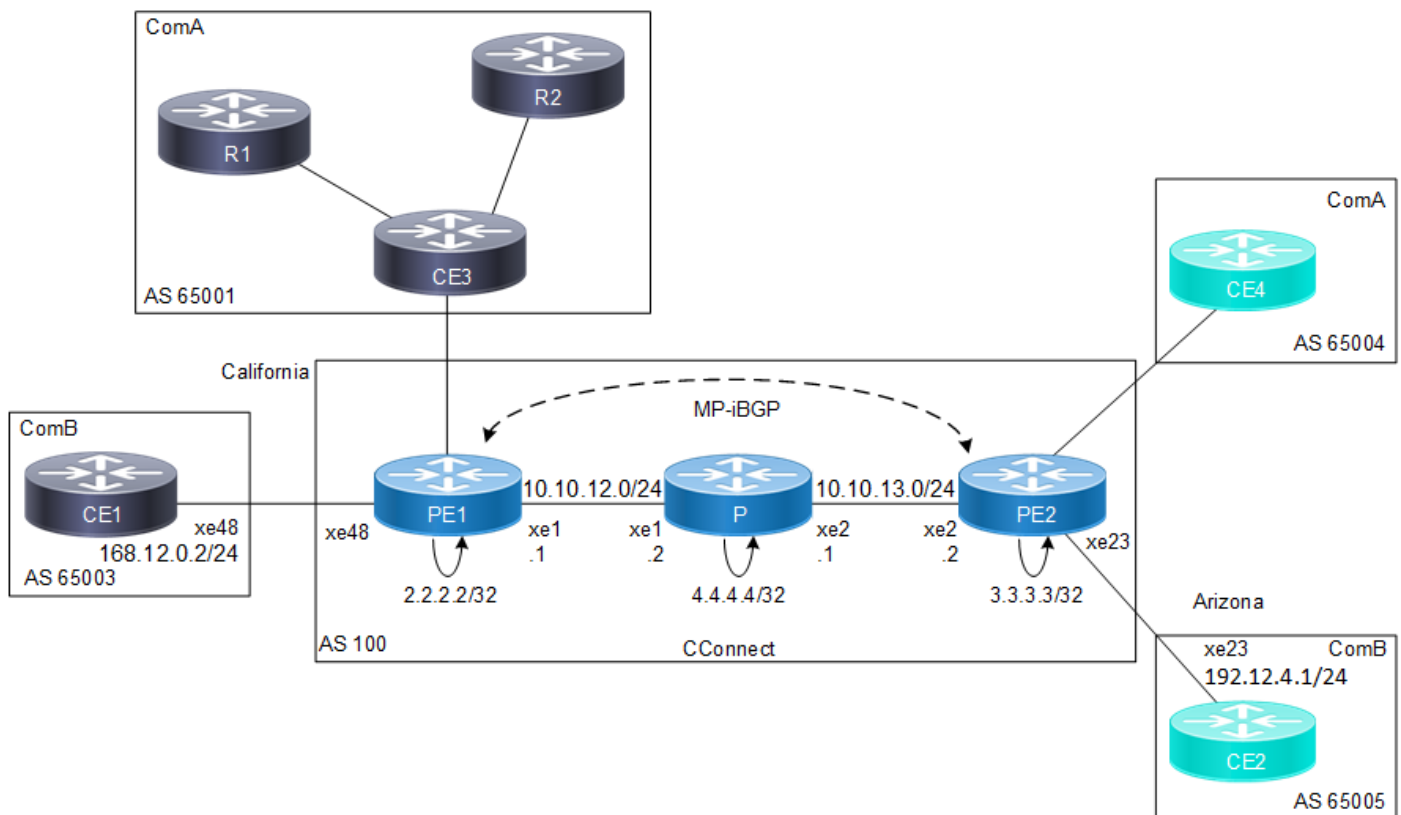


Figure 3-14: CConnect Provider with ComA and ComB Customers

- **Service Provider**
The organization that owns the infrastructure that provides leased lines to customers, offering them a Virtual Private Network Service. In the above illustration, CConnect is the service provider providing services to clients ComA and ComB.
- **Customer Edge (CE) Router**
A router at a customer's site that connects to the Service Provider via one or more Provider Edge routers. In the above illustration, CE1, CE2, CE3 and CE4 are all CE routers connected directly to the CConnect network.

- **Provider Edge (PE) Router**

A provider's router connected to a CE router through a leased line or dial-up connection. In the above illustration, PE1 and PE2 are the PE routers, because they link the CConnect service provider to its clients.

- **Provider Core Router (P)**

The devices in the core of the service provider network, which are generally not Provider Edge routers. In the above illustration, the P router is the Provider device, not connected to any customer, and is the core of the CConnect network.

- **Site**

A contiguous part of the customer network. A site connects to the provider network through transmission lines, using a CE and PE router. In the above illustration, R1, R2 and CE3 comprise a Customer network, and are seen as a single site by the CConnect network.

- **Customer Router**

In the illustration above, R1 and R2 are the Customer routers, and are not directly connected to the CConnect network.

VPN Routing Process

The OcNOS MPLS-VPN Routing process follows these steps:

1. Service Providers provide VPN services from PE routers that communicate directly with CE routers via an Ethernet Link.
2. Each PE router maintains a Routing and Forwarding table (VRF) for each customer. This guarantees isolation, and allows the usage of uncoordinated private addresses. When a packet is received from the CE, the VRF that is mapped to that site is used to determine the routing for the data. If a PE has multiple connections to the same site, a single VRF is mapped to all of those connections.
3. After the PE router learns of the IP prefix, it converts it into a VPN-IPv4 prefix by prepending it with an 8-byte Route Distinguisher (RD). The RD ensures that even if two customers have the same address, two separate routes to that address can be maintained. These VPN-IPv4 addresses are exchanged between the PE routers through MP-BGP.
4. A unique Router ID (usually the loopback address) is used to allocate a label, and enable VPN packet forwarding across the backbone.
5. Based on routing information stored in the VRF table, packets are forwarded to their destination using MPLS. Each PE router allocates a unique label to every route in each VRF (even if they have the same next hop), and propagates these labels, together with 12-byte VPN-IPv4 addresses, through Multi-Protocol BGP.
6. Ingress PE routers prepend a two-level label stack to the VPN packet, which is forwarded across the Provider network. This label stack contains a BGP-specific label from the VRF table (associated with the incoming interface), specifying the BGP next hop and an LDP-specific label from the global FTN table, specifying the IP next hop.
7. The Provider router in the network switches the VPN packet, based on the top label or the LDP-specific label in the stack. This top label is used as the key to lookup in the incoming interface's Incoming Labels Mapping table (ILM). If there is an outbound label, the label is swapped, and the packet is forwarded to the next hop; if not, the router is the penultimate router, and it pops the LDP-specific label, and forwards the packet with only the BGP-specific label to the egress PE router.
8. The egress PE router pops the BGP-specific label, performs a single label lookup in the outbound interface, and sends the packet to the appropriate CE router.

Configure MPLS Layer-3 VPN

The MPLS Layer-3 VPN configuration process can be divided into the following tasks

1. Establish connection between PE routers.
2. Configure PE1 and PE2 as iBGP neighbors.
3. Create VRF.
4. Associate interfaces to VRFs.
5. Configure VRF Route Destination and Route Targets.
6. Configure CE neighbor for the VPN.
7. Verify the MPLS to VPN configuration.

Topology

In this example, the CConnect MPLS-VPN backbone has two customers — ComA and ComB. Both customers have sites in California and Arizona. The following topology shows BGP4 address assignment between PE and CE routers. The steps that follow provision a customer VPN service across the MPLS-VPN backbone.

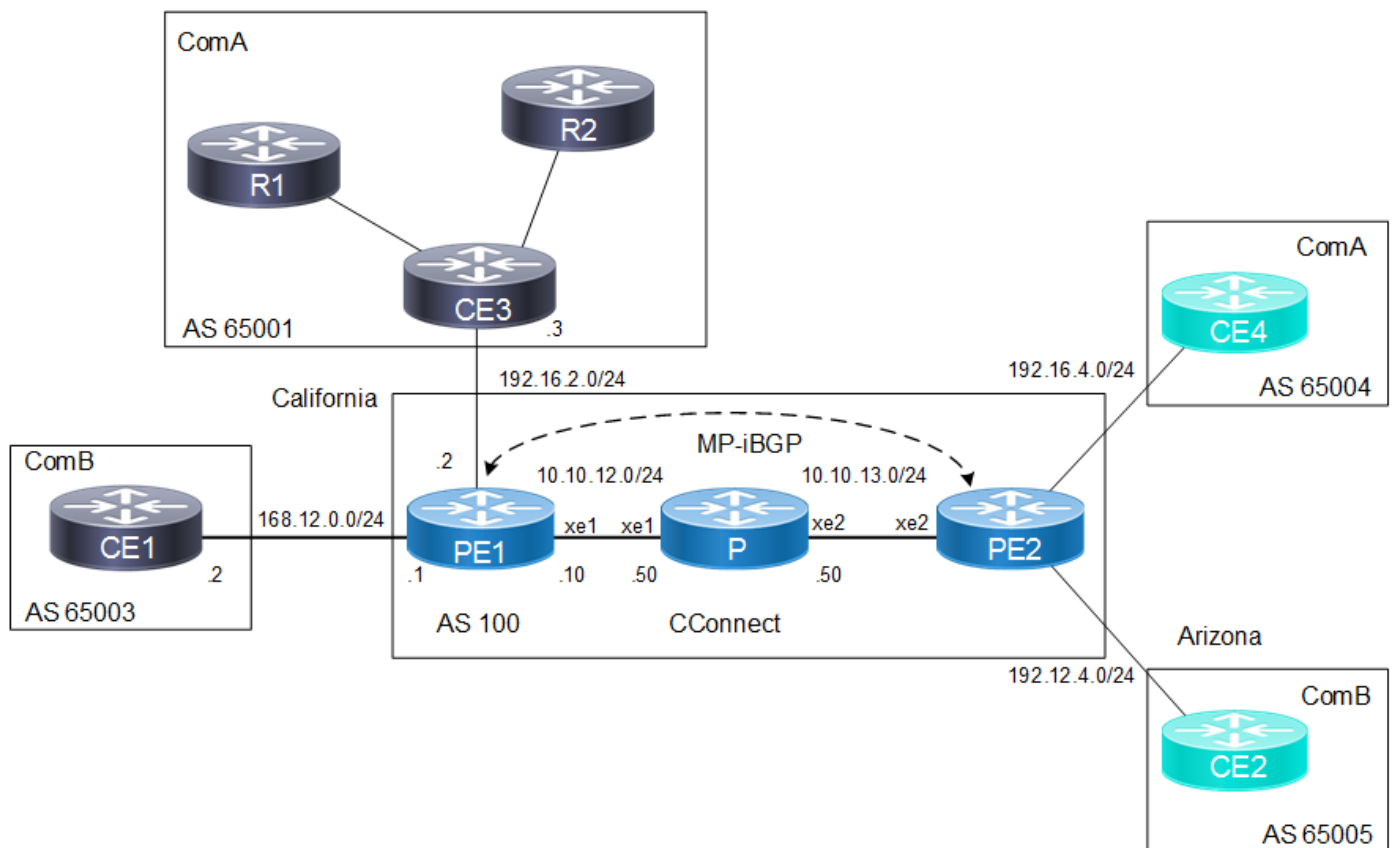


Figure 3-15: Connect Sample Topology

To establish this connection involves three steps:

Enable Label Switching

This is a sample configuration to enable label switching for the Labeled Switched Path (LSP) between PE1 and PE2 (refer to [Figure 3-15](#)).

Enable Label Switching: PE1

configure terminal	Enter configure mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 2.2.2.2/32 secondary	Assign the IPv4 address
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter Interface mode
(config-if)#ip address 10.10.12.1/24	Assign IPv4 address
(config-if)#label-switching	Enabling label switching capability on router
(config-if)#commit	Commit the transaction.

Enable Label Switching: P

configure terminal	Enter configure mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 4.4.4.4/32 area 0 secondary	Assign the IPv4 address
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter Interface mode
(config-if)#ip address 10.10.12.2/24	Assign IPv4 address
(config-if)#label-switching	Enabling label switching capability on router
(config-if)#commit	Commit the transaction.
(config)#interface xe2	Enter Interface mode
(config-if)#ip address 10.10.13.1/24	Assign IPv4 address
(config-if)#label-switching	Enabling label switching capability on router
(config-if)#commit	Commit the transaction.

Enable Label Switching: PE2

configure terminal	Enter configure mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Assign the IPv4 address
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter Interface mode
(config-if)#ip address 10.10.13.2/24	Assign IPv4 address
(config-if)#label-switching	Enabling label switching capability on router
(config-if)#commit	Commit the transaction.

Enable IGP

What follows is a sample configuration to establish connections between the two Provider Edge routers PE1 and PE2.

Enable IGP Switching: PE1

configure terminal	Enter configure mode
(config)#router ospf 100	Configure the routing process and specify the Process ID (100)
(config-router)#network 10.10.12.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
(config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
(config-router)#commit	Commit the transaction.

Enable IGP Switching: P

configure terminal	Enter configure mode
(config)#router ospf 100	Configure the routing process and specify the Process ID (100)
(config-router)#network 10.10.12.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
(config-router)#network 10.10.13.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
(config-router)#network 4.4.4.4/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
(config-router)#commit	Commit the transaction.

Enable IGP Switching: PE2

configure terminal	Enter configure mode
(config)#router ospf 100	Configure the routing process and specify the Process ID (100)
(config-router)#network 3.3.3.3/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
(config-router)#commit	Commit the transaction.

Enable Label Switching Protocol

Label switching protocols are used to set up a Label-Switched Path (LSP) between PE routers. OcNOS supports LDP and RSVP-TE protocols for label switching. Enable either LDP or RSVP-TE.

This is a sample configuration to enable LDP on the whole path between PE1 and PE2 (see [Figure 3-15](#)).

LDP: PE1

configure terminal	Enter configure mode
(config)#router ldp	Enter router mode for LDP

(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode
(config-if)#enable-ldp ipv4	Enabling LDP on interface
(config-if)#commit	Commit the transaction.

LDP: P

configure terminal	Enter configure mode
(config)#router ldp	Enter router mode for LDP
(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode
(config-if)#enable-ldp ipv4	Enabling LDP on interface
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode
(config-if)#enable-ldp ipv4	Enabling LDP on interface
(config-if)#commit	Commit the transaction.

LDP: PE2

configure terminal	Enter configure mode
(config)#router ldp	Enter router mode for LDP
(config-router)#exit	Exit router mode
(config)#interface xe2	Enter interface mode
(config-if)#enable-ldp ipv4	Enabling LDP on interface
(config-if)#commit	Commit the transaction.

This is a sample configuration to enable RSVP-TE along the entire path between PE1 and PE2 (see [Figure 3-15](#)).

RSVP-TE: PE1

configure terminal	Enter configure mode
(config)#router rsvp	Enter Configure Router mode
(config-router)#rsvp-path p1 mpls	Enter the path mode for RSVP P1.
(config-path)#10.10.12.2 loose	Configure loose path
(config-path)#exit	Exit Configure Router mode
(config)#rsvp-trunk t1	Configure RSVP trunk t1
(config-rsvp)#primary path p1	Specify an RSVP path to be used
(config-rsvp)#from 2.2.2.2	Assign the source loopback address to the RSVP trunk
(config-rsvp)#to 3.3.3.3	Assign the source loopback address to the to the RSVP trunk
(config-rsvp)#exit	Exit RSVP trunk mode
(config)#interface xe1	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP in interface
(config-if)#commit	Commit the transaction.

RSVP-TE: P

configure terminal	Enter configure mode
(config)#router rsvp	Enter Configure Router mode
(config-router)#exit	Exit Configure Router mode
(config)#interface xe1	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP in interface
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP in interface
(config-if)#commit	Commit the transaction.

RSVP-TE: PE2

configure terminal	Enter configure mode
(config)#router rsvp	Enter Configure Router mode
(config-router)#rsvp-trunk t1	Configure RSVP trunk t1
(config-rsvp)#from 3.3.3.3	Assign the source loopback address to the RSVP trunk
(config-rsvp)#to 2.2.2.2	Assign the source loopback address to the to the RSVP trunk
(config-rsvp)#exit	Exit RSVP trunk mode
(config)#interface xe2	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP in interface
(config-if)#commit	Commit the transaction.

Configure PEs as BGP Neighbors

BGP is the preferred protocol to transport VPN routes because of its multiprotocol capability and its scalability. Its ability to exchange information between indirectly connected routers supports keeping VPN routing information out of the Provider (P) routers. The P routers carry information as an optional BGP attribute. Additional attributes are transparently forwarded by any P router. The MPLS-VPN forwarding model does not require the P routers to make routing decisions based on VPN addresses: They forward packets based on the label value attached to the packet. The P routers do not require a VPN configuration in order to carry this information.

PE1

#configure terminal	Enter the configure terminal
(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)#bgp router-id 2.2.2.2	Router identifier for BGP
(config-router)#exit	Exit router BGP mode
(config)#router ldp	Enter the Router LDP mode
(config-router)#exit	Exit the Router LDP mode
(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)#neighbor 3.3.3.3 remote-as 100	Configuring ABR1 as iBGP neighbor using it's loopback IP

(config-router)#neighbor 3.3.3.3 update-source 2.2.2.2	Source of routing updates
(config-router)#address-family vpnv4 unicast	Configure VPNv4 address family
(config-router-af)#neighbor 3.3.3.3 activate	Activate the VPN neighbor
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#address-family ipv4 unicast	Configure IPv4 address family
(config-router-af)#neighbor 3.3.3.3 activate	Activate the IPv4 neighbor
(config-router-af)#commit	Commit the transaction.

PE2

#configure terminal	Enter the configure terminal
(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)#bgp router-id 3.3.3.3	Router identifier for BGP
(config-router)#exit	Exit router BGP mode
(config)#router ldp	Enter the Router LDP mode
(config-router)#exit	Exit the Router LDP mode
(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)#neighbor 2.2.2.2 remote-as 100	Configuring ABR1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 2.2.2.2 update-source 3.3.3.3	Source of routing updates
(config-router)#address-family vpnv4 unicast	Configure VPNv4 address family
(config-router-af)#neighbor 2.2.2.2 activate	Activate the VPN neighbor
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#address-family ipv4 unicast	Configure IPv4 address family
(config-router-af)#neighbor 2.2.2.2 activate	Activate the IPv4 neighbor
(config-router-af)#commit	Commit the transaction.

Create VRF

Each PE router in the MPLS-VPN backbone is attached to a site that receives routes from a specific VPN, so the PE router must have the relevant Virtual Routing and Forwarding (VRF) configuration for that VPN.

This command creates a VRF RIB (Routing Information Base), assigns a VRF-ID, and switches the command mode to `vrf` mode. The following example creates a VRF named `ComB`.

PE1

#configure terminal	Enter the configure terminal
(config)#ip vrf ComB	Configure VRF instance
(config-vrf)#rd 2:1	Configure Router Distinguisher value
(config-vrf)#exit	Exit VRF mode
(config)#ip vrf ComA	Configure VRF instance
(config-vrf)#rd 1:2	Configure Router Distinguisher value

(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the transaction.

PE2

#configure terminal	Enter the configure terminal
(config)#ip vrf ComB	Configure VRF instance
(config-vrf)#rd 1:2	Configure Router Distinguisher value
(config-vrf)#exit	Exit VRF mode
(config)#ip vrf ComA	Configure VRF instance
(config-vrf)#rd 2:1	Configure Router Distinguisher value
(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the transaction.

Associate Interfaces to VRFs

After the VRFs are defined on the PE router, the PE router needs to recognize which interfaces belong to which VRF. The VRF is populated with routes from connected sites. More than one interface can belong to the same VRF.

In the following example, interface `xe48` is associated with the VRF named `ComB`.

PE1

#configure terminal	Enter the configure terminal
(config)#interface xe49	Enter interface mode
(config-if)#ip vrf forwarding ComA	Bind the VRF instance to the interface
(config-if)#exit	Exit interface mode
(config)#interface xe48	Enter interface mode
(config-if)#ip vrf forwarding ComB	Bind the VRF instance to the interface
(config-if)#ip address 168.12.0.3/24	Assign IPv4 address
PE1(config-if)#ip vrf forwarding ComA	Bind the VRF instance to the interface
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

PE2

#configure terminal	Enter the configure terminal
(config)#interface xe48	Enter interface mode
(config-if)#ip vrf forwarding ComA	Bind the VRF instance to the interface
(config-if)#ip address 192.16.4.2/24	Assign IPv4 address
(config-if)#exit	Exit interface mode
(config)#interface xe49	Enter interface mode
(config-if)#ip vrf forwarding ComB	Bind the VRF instance to the interface
(config-if)#ip address 168.12.4.2/24	Assign IPv4 address

(config-if)exit	Exit interface mode
(config)#commit	Commit the transaction.

Configure VRF—RD and Route Targets

After the VRF is created, configure Router Distinguishers and the Route Targets.

Configure Route Distinguishers

Route Distinguishers (RDs) make all customer routes unique. The routes must be unique, so that Multi-Protocol BGP treats the same prefix from two different VPNs as non-comparable routes. To configure RDs, a sequence of 64 bits is prepended to the IPv4 address in the Multi-Protocol BGP update. BGP considers two IPv4 addresses with different RDs as non-comparable, even if they have the same address and mask.

Assign a particular value to the RD for each VRF on the PE router. To display the routing table for a VRF, use the `show ip route vrf` command.

The following example shows adding an RD. Configure a VRF in both PEs with a unique RD value:

PE1

#configure terminal	Enter the configure terminal
(config)#ip vrf ComA	Configure VRF instance
(config-vrf)#rd 2:2	Configure Router Distinguisher value
(config-vrf)#route-target both 200:1	Configure route-target as both
(config-vrf)#exit	Exit VRF mode
(config)#ip vrf ComB	Configure VRF instance
(config-vrf)#rd 1:1	Configure Router Distinguisher value
(config-vrf)#route-target both 100:1	Configure route-target as both
(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the transaction.

PE2

#configure terminal	Enter the configure terminal
(config)#ip vrf ComA	Configure VRF instance
(config-vrf)#rd 2:1	Configure Router Distinguisher value
(config-vrf)#route-target both 200:1	Configure route-target as both
(config-vrf)#exit	Exit VRF mode
(config)#ip vrf ComB	Configure VRF instance
(config-vrf)#rd 1:2	Configure Router Distinguisher value
(config-vrf)#route-target both 100:1	Configure route-target as both
(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the transaction.

Configure Route Targets

Any routes learned from customers are advertised across the network through Multi-Protocol BGP, and any routes learned through Multi-Protocol BGP are added into the appropriate VRFs. The route target helps PE routers identify which VRFs should receive the routes.

The `route-target` command creates lists of import and export route-target extended communities for the VRF. It specifies a target VPN extended community. Execute the command once for each community. All routes with the specific route-target extended community are imported into all VRFs with the same extended community as an import route-target.

The following example demonstrates the route-target configuration.

PE1

#configure terminal	Enter the configure terminal
(config)#ip vrf ComA	Configure VRF instance
(config-vrf)#rd 2:2	Configure Router Distinguisher value
(config-vrf)#route-target both 200:1	Configure route-target as both
(config-vrf)#exit	Exit VRF mode
(config)#ip vrf ComB	Configure VRF instance
(config-vrf)#rd 1:1	Configure Router Distinguisher value
(config-vrf)#route-target both 100:1	Configure route-target as both
(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the transaction.

PE2

#configure terminal	Enter the configure terminal
(config)#ip vrf ComA	Configure VRF instance
(config-vrf)#rd 2:1	Configure Router Distinguisher value
(config-vrf)#route-target both 200:1	Configure route-target as both
(config-vrf)#exit	Exit VRF mode
(config)#ip vrf ComB	Configure VRF instance
(config-vrf)#rd 1:2	Configure Router Distinguisher value
(config-vrf)#route-target both 100:1	Configure route-target as both
(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the transaction.

Configure CE Neighbor for the VPN (Using BGP/ OSPF)

To provide a VPN service, the PE-router must be configured so that any routing information learned from a VPN customer interface can be associated with a particular VRF. This is achieved using any standard routing protocol process (OSPF, BGP or static routes etc). Use any one of the following configurations (BGP, or OSPF) to configure the CE neighbor.

Using BGP

The BGP sessions between PE and CE routers can carry different types of routes (VPN-IPv4, IPv4 routes). Address families are used to control the type of BGP session. Configure a BGP address family for each VRF on the PE-router, and a separate address family to carry VPN-IPv4 routes between PE routers. All non-VPN BGP neighbors are defined using the `IPv4 address mode`. Each VPN BGP neighbor is defined under its associated address family mode.

A separate address family entry is used for every VRF, and each address family entry can have multiple CE routers within the VRF.

The PE and CE routers must be directly connected for BGP4 sessions; BGP multihop is not supported between PE and CE routers.

The following example places the router in address family mode, and specifies company names, `ComA` and `ComB`, as the names of the VRF instance to associate with subsequent IPv4 address family configuration mode commands. This configuration is used when BGP is used for PE and CE.

PE1

<code>configure terminal</code>	Enter configure mode
<code>(config)#router bgp 100</code>	Enter BGP router mode
<code>(config-router)#address-family ipv4 unicast</code>	Enter address family mode
<code>(config-router-af)#redistribute connected</code>	Redistribute connected addresses
<code>(config-router-af)#exit-address-family</code>	Exit address family mode
<code>(config-router)#address-family ipv4 vrf ComA</code>	Enter the IPv4 address family for VRF comA
<code>(config-router)#neighbor 192.16.2.3 remote-as 65001</code>	Specify the neighbor
<code>(config-router-af)#neighbor 192.16.2.3 activate</code>	Activate the neighbor
<code>(config-router-af)#exit-address-family</code>	Exit address family mode
<code>(config-router)#address-family ipv4 vrf ComB</code>	Enter the IPv4 address family for VRF comA
<code>(config-router)#neighbor 168.12.0.2 remote-as 65003</code>	Specify the neighbor
<code>(config-router-af)#neighbor 192.12.0.2 activate</code>	Activate the neighbor
<code>(config-router-af)#exit-address-family</code>	Exit address family mode
<code>(config-router)#commit</code>	Commit the transaction

PE2

<code>configure terminal</code>	Enter configure mode
<code>(config)#router bgp 100</code>	Enter BGP router mode
<code>(config-router)#address-family ipv4 unicast</code>	Enter address family mode
<code>(config-router-af)#redistribute connected</code>	Redistribute connected addresses
<code>(config-router-af)#exit-address-family</code>	Exit address family mode
<code>(config-router)#address-family ipv4 vrf ComA</code>	Enter the IPv4 address family for VRF comA
<code>(config-router)#neighbor 192.16.4.3 remote-as 65004</code>	Specify the neighbor

(config-router-af)#neighbor 192.16.4.3 activate	Activate the neighbor
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#address-family ipv4 vrf ComB	Enter the IPv4 address family for VRF comA
(config-router)#neighbor 168.12.4.1 remote- as 65005	Specify the neighbor
(config-router-af)#neighbor 192.12.4.1 activate	Activate the neighbor
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#commit	Commit the transaction

CE1: BGP

configure terminal	Enter configure mode
(config)#interface xe48	Enter interface mode for xe48
(config-if)#ip address 168.12.0.2/24	Assign IP address
(config-if)#exit	Exit interface mode
(config)#router bgp 65003	Enter BGP router mode
(config-router)#neighbor 168.12.0.3 remote- as 100	Specify the neighbor
(config-router)#address-family ipv4 unicast	Enter address family mode
(config-router-af)#neighbor 168.12.0.3 activate	Activate the neighbor
(config-router-af)#redistribute connected	Redistribute connected addresses
(config-router-af)#commit	Commit the transaction

CE2: BGP

configure terminal	Enter configure mode
(config)#interface xe23	Enter interface mode for xe48
(config-if)#ip address 192.12.4.1/24	Assign IP address
(config-if)#exit	Exit interface mode
(config)#router bgp 65005	Enter BGP router mode
(config-router)#neighbor 192.12.4.2 remote- as 100	Specify the neighbor
(config-router)#address-family ipv4 unicast	Enter address family mode
(config-router-af)#neighbor 192.12.4.2 activate	Activate the neighbor
(config-router-af)#redistribute connected	Redistribute connected addresses
(config-router-af)#commit	Commit the transaction

Using OSPF

Unlike BGP, OSPF does not run different routing contexts within one process. Thus, for running OSPF between the PE and CE routers, configure a separate OSPF process for each VRF that receives VPN routes through OSPF. The PE

router distinguishes routers belonging to a specific VRF, by associating a particular customer interface to a specific VRF and to a particular OSPF process.

To redistribute VRF OSPF routes into BGP, redistribute OSPF under the BGP VRF address family submode.

PE1

configure terminal	Enter configure mode
(config)#router ospf 101 comA	Enter OSPF router mode
(config-router)#network 192.16.3.0/24 area 0	Define the network on which OSPF runs and associate area ID
(config-router)#redistribute bgp	Redistribute BGP
(config-router)#exit	Exit router mode
(config)#router ospf 102 comB	Enter OSPF router mode
(config-router)#network 168.12.0.2/24 area 0	Define the network on which OSPF runs and associate area ID
(config-router)#redistribute bgp	Redistribute BGP
(config-router)#commit	Commit the transaction
(config-router)#exit	Exit router mode
(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)#address-family ipv4 vrf ComA	Configure VRF address family
(config-router-af)#redistribute ospf	Redistribute OSPF
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#address-family ipv4 vrf ComB	Configure VRF address family
(config-router-af)#redistribute ospf	Redistribute OSPF
(config-router-af)#redistribute rip	Redistribute RIP
(config-router-af)#commit	Commit the transaction

PE2

configure terminal	Enter configure mode
(config)#router ospf 101 comA	Enter OSPF router mode
(config-router)#network 192.16.4.0/24 area 0	Define the network on which OSPF runs and associate area ID
(config-router)#redistribute bgp	Redistribute BGP
(config-router)#exit	Exit router mode
(config)#router ospf 102 comB	Enter OSPF router mode
(config-router)#network 168.12.0.3/24 area 0	Define the network on which OSPF runs and associate area ID
(config-router)#redistribute bgp	Redistribute BGP
(config-router)#commit	Commit the transaction
(config-router)#exit	Exit router mode
(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)#address-family ipv4 vrf ComA	Configure VRF address family
(config-router-af)#redistribute ospf	Redistribute OSPF

(config-router-af)#exit-address-family	Exit address family mode
(config-router)#address-family ipv4 vrf ComB	Configure VRF address family
(config-router-af)#redistribute ospf	Redistribute OSPF
(config-router-af)#redistribute rip	Redistribute RIP
(config-router-af)#commit	Commit the transaction

Verify the MPLS-VPN Configuration

Use the `show ip bgp neighbor` command to validate the neighbor session between the CE and the PE routers. Use the `show ip bgp vpnv4 all` command to display all the VRFs and the routes associated with them. The following is sample output for the above commands for the PE1, CE1 and PE2 routers (based on the topology in [Figure 3-15](#)).

```
PE1#show ip bgp neighbors
BGP neighbor is 3.3.3.3, remote AS 100, local AS 100, internal link
  BGP version 4, local router ID 2.2.2.2, remote router ID 3.3.3.3
  BGP state = Established, up for 00:05:09
  Last read 00:00:13, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
    Address family VPNv4 Unicast: advertised and received
  Received 194 messages, 2 notifications, 0 in queue
  Sent 198 messages, 3 notifications, 0 in queue
  Route refresh request: received 2, sent 1
  Minimum time between advertisement runs is 5 seconds
  Update source is 2.2.2.2
For address family: IPv4 Unicast
  BGP table version 8, neighbor version 8
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  3 accepted prefixes
  3 announced prefixes

For address family: VPNv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  0 accepted prefixes
  2 announced prefixes

Connections established 5; dropped 4
Local host: 2.2.2.2, Local port: 35983
Foreign host: 3.3.3.3, Foreign port: 179
Nexthop: 2.2.2.2
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
Last Reset: 00:05:14, due to BGP Notification received
Notification Error Message: (Cease/Other Configuration Change.)

BGP neighbor is 168.12.0.2, vrf ComB, remote AS 65003, local AS 100, external
link
```

```
BGP version 4, local router ID 168.12.0.3, remote router ID 10.12.65.206
BGP state = Established, up for 00:34:38
Last read 00:00:14, hold time is 90, keepalive interval is 30 seconds
Neighbor capabilities:
  Route refresh: advertised and received (old and new)
  Address family IPv4 Unicast: advertised and received
Received 85 messages, 0 notifications, 0 in queue
Sent 86 messages, 0 notifications, 0 in queue
Route refresh request: received 0, sent 0
Minimum time between advertisement runs is 30 seconds
For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (standard)
  2 accepted prefixes
  0 announced prefixes

Connections established 1; dropped 0
Local host: 168.12.0.3, Local port: 179
Foreign host: 168.12.0.2, Foreign port: 36580
Nexthop: 168.12.0.3
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

CE1#show ip bgp neighbors
BGP neighbor is 168.12.0.3, remote AS 100, local AS 65003, external link
  BGP version 4, local router ID 10.12.65.206, remote router ID 168.12.0.3
  BGP state = Established, up for 00:36:14
  Last read 00:00:10, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
  Received 86 messages, 0 notifications, 0 in queue
  Sent 89 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 30 seconds
  For address family: IPv4 Unicast
    BGP table version 1, neighbor version 1
    Index 1, Offset 0, Mask 0x2
    Community attribute sent to this neighbor (both)
    0 accepted prefixes
    2 announced prefixes

Connections established 1; dropped 0
Local host: 168.12.0.2, Local port: 36580
Foreign host: 168.12.0.3, Foreign port: 179
Nexthop: 168.12.0.2
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

PE1#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best,
i - internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
```

```

Network          Next Hop          Metric    LocPrf    Weight Path
Route Distinguisher: 1:1 (Default for VRF ComB)
*> 1 168.12.0.0/24 0.0.0.0          1          100          32768 ?
                        168.12.0.2          0          100          0 65003 ?
*>i 192.12.4.0      3.3.3.3          0          100          0 65005 ?
  Announced routes count = 2
  Accepted routes count = 1
Route Distinguisher: 1:2
*>i 192.12.4.0      3.3.3.3          0          100          0 65005 ?
  Announced routes count = 0
  Accepted routes count = 1
Route Distinguisher: 2:2 (Default for VRF ComA)
*> 1 192.16.2.0      0.0.0.0          1          100          32768 ?
                        192.16.2.3          0          100          0 65001 ?
  Announced routes count = 2
  Accepted routes count = 0

```

PE1#show ip bgp vpnv4 all neighbors 3.3.3.3 routes

For address family: VPNv4 Unicast

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best,
i - internal, l - labeled

S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

```

Network          Next Hop          Metric    LocPrf    Weight Path
Route Distinguisher: 1:2
*>i 192.12.4.0      3.3.3.3          0          100          0 65005 ?
  Accepted routes count = 1

```

PE2#show ip bgp vpnv4 all

Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled

S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

```

Network          Next Hop          Metric    LocPrf    Weight Path
Route Distinguisher: 1:2 (Default for VRF ComB)
*>i 168.12.0.0/24 2.2.2.2          0          100          0 ?
*> 1 192.12.4.0      0.0.0.0          0          100          32768 ?
  Announced routes count = 1
  Accepted routes count = 1
Route Distinguisher: 1:2
*>i 168.12.0.0/24 2.2.2.2          0          100          0 ?
  Announced routes count = 0
  Accepted routes count = 1

```

Verify MPLS-L3 VPN VRF Ping and Traceroute

Use the ping mpls l3vpn command for the below requirements:

- PE to PE L3VPN ping via VRF
- PE to remote CE Ping via the VRF
- CE to remote PE ping (to the VRF interface facing its customer edge).

- Trace route from PE to PE via VRF
- Trace route from PE to remote CE via VRF
- Commands for ipv6 ping and trace route

1. PE to PE L3VPN Ping via VRF:

```
PE2#ping 168.12.0.1 vrf ComB
Press CTRL+C to exit
PING 168.12.0.1 (168.12.0.1) 56(84) bytes of data.
64 bytes from 168.12.0.1: icmp_seq=1 ttl=64 time=0.695 ms

#
```

2. PE to remote CE Ping via VRF:

```
PE2#ping 168.12.0.2 vrf ComB
Press CTRL+C to exit
PING 168.12.0.2 (168.12.0.2) 56(84) bytes of data.
64 bytes from 168.12.0.2: icmp_seq=1 ttl=63 time=0.776 ms

--- 168.12.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.776/0.776/0.776/0.000 ms
PE2#
PE2
```

3. CE to remote PE ping:

```
CE1#ping 168.12.0.1
Press CTRL+C to exit
PING 168.12.0.1 (168.12.0.1) 56(84) bytes of data.
64 bytes from 168.12.0.1: icmp_seq=160 ttl=254 time=0.606 ms
64 bytes from 168.12.0.1: icmp_seq=161 ttl=254 time=0.558 ms
64 bytes from 168.12.0.1: icmp_seq=162 ttl=254 time=0.568 ms
64 bytes from 168.12.0.1: icmp_seq=163 ttl=254 time=0.574 ms
64 bytes from 168.12.0.1: icmp_seq=164 ttl=254 time=0.609 ms

--- 168.12.0.2 ping statistics ---
5 packets transmitted, 5 received, 0 errors, 0% packet loss, time 163002ms
```

4. Trace Route from PE to PE via VRF

```
PE2#traceroute ip 168.12.0.1 vrf ComB
traceroute to 168.12.0.1 (168.12.0.1), 30 hops max, 60 byte packets
1 168.12.0.1 (168.12.0.1) 0.706 ms 0.743 ms 0.989 ms
```

5. Trace Route from PE to Remote CE via VRF

```
PE2#traceroute ip 168.12.0.2 vrf ComB
traceroute to 168.12.0.2 (168.12.0.2), 30 hops max, 60 byte packets
1 168.12.0.1 (168.12.0.1) 0.871 ms 1.006 ms 1.055 ms
2 168.12.0.2 (168.12.0.2) 1.965 ms 2.045 ms 2.256 ms
```

CHAPTER 4 MPLS-TE Shared Risk Link Group

Shared Risk Link Groups (SRLG) is a feature which allows the user to establish a backup secondary LSP (label switched path) path or a FRR (fast-reroute) LSP path which is disjoint from the path of the primary LSP. Links which are members of the same SRLG represent resources which share the same risk. For example, fiber links sharing the same conduit or multiple wavelengths sharing the same fiber.

SRLG groups are used to determine which links belong to the same SRLG. To advertise SRLG, the information is part of the IGP TE parameters in an opaque LSA (link state advertisement). It is advertised in a SRLG sub-TLV (type 16) of the existing Link TLV in OSPF.

The SRLG of a path in a label-switched path (LSP) is the set of SRLGs for all the links in the path. When computing the secondary path for an LSP, it is preferable to find a path such that the secondary and primary paths do not have any links in common in case the SRLGs for the primary and secondary paths are disjoint. This ensures that a single point of failure on a particular link does not bring down both the primary and secondary paths in the LSP.

Backup tunnel path selection with SRLG is done so that a backup tunnel can avoid using links that are in the same SRLG as the interfaces it is protecting. Otherwise, when the protected link fails the backup tunnel fails too.

Configure MPLS-TE Shared Risk Link Group

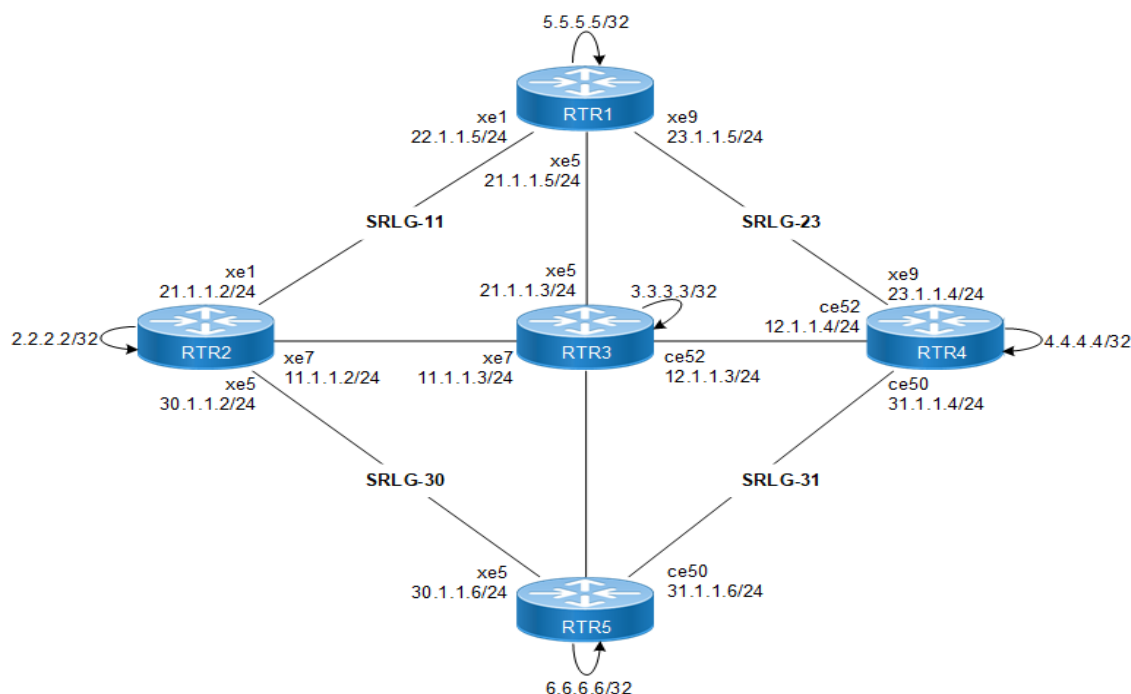


Figure 4-1: Topology for SRLG

RTR2

Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address on loopback interface.
(config-if)#commit	Commit the transaction.

MPLS Interface

(config)#interface xe1	Enter the Interface mode
(config-if)#ip address 22.1.1.2/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe5	Enter the Interface mode
(config-if)#ip address 30.1.1.2/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe7	Enter the Interface mode
(config-if)#ip address 11.1.1.2/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#commit	Commit the transaction.

OSPF

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#router-id 2.2.2.2	Configure OSPF router id
(config-router)#network 2.2.2.2/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 11.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 22.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 30.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#commit	Commit the transaction.

Global RSVP

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#commit	Commit the transaction.

RSVP Interface

(config)#interface xe1	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface

(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe5	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe7	Enter the Interface mode
(config-if)#enable-rsvp	Enable rsvp on the interface
(config-if)#commit	Commit the transaction.

Global SRLG (Path Type: Forced)

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#srlg-disjoint forced	Configure SRLG path type forced
(config-router)#commit	Commit the transaction.

Note: Disjoint type “preferred” can be configured globally using the command `srlg-disjoint preferred`.

SRLG Interface

(config)#interface xe1	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 11	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe7	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 11	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe5	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 30	Configure SRLG value in the interface
(config-if)#commit	Commit the transaction.

MPLS RSVP Path

(config)#rsvp-path path1	Configure MPLS-path
(config-path)#11.1.1.3 strict	Configure first hop for the path
(config-path)#12.1.1.4 strict	Configure second hop for the path
(config-path)#exit	Exit mpls-path mode and return to Configure mode.
(config)#rsvp-path sec-path1	Configure MPLS-path
(config-path)#4.4.4.4 loose	Configure loose path
(config-path)#exit	Exit mpls-path mode and return to Configure mode.
(config-path)#rsvp-path sec-path2	Configure MPLS-path.
(config-path)#4.4.4.4 loose	Configure loose path
(config-path)#commit	Commit the transaction.

RSVP-TE Tunnel with Secondary Protection and SRLG Disjoint Type Forced:

#configure terminal	Enter configure mode.
(config)#rsvp-trunk lsp1	Configure rsvp trunk
(config-trunk)#primary path path1	Configure primary path
(config-trunk)#secondary-priority 1 path sec-path1	Configure secondary path
(config-trunk)#secondary-priority 1 srlg-disjoint forced	Configure SRLG for secondary path
(config-trunk)#secondary-priority 2 path sec-path2	Configure secondary path
(config-trunk)#secondary-priority 2 srlg-disjoint forced	Configure SRLG for secondary path
(config-trunk)#to 4.4.4.4	Configure rsvp trunk destination address
(config-trunk)#commit	Commit the transaction.

Note: Disjoint type preferred can be configured in rsvp-trunk secondary using the command "secondary-priority 2 srlg-disjoint forced.

RSVP-TE Tunnel with Fast Reroute Protection One-to-One

#configure terminal	Enter configure mode.
(config)#rsvp-trunk lsp2	Configure rsvp trunk
(config-trunk)#primary fast-reroute protection one-to-one	Configure fast-reroute protection
(config-trunk)#primary path path1	Configure primary path
(config-trunk)#to 4.4.4.4	Configure rsvp trunk destination address
(config-trunk)#commit	Commit the transaction.

RSVP-TE Tunnel with Fast Reroute Protection Facility Backup

#configure terminal	Enter configure mode.
(config)#rsvp-bypass bypass1	Configure rsvp bypass tunnel
(config-bypass)#path path1	Configure path for bypass tunnel
(config-bypass)#to 4.4.4.4	Configure destination address for tunnel
(config-bypass)#exit	Exit rsvp-bypass tunnel mode
(config)#rsvp-trunk lsp3	Configure rsvp trunk
(config-trunk)#primary fast-reroute protection facility	Configure fast-reroute protection facility
(config-trunk)#primary path sec-path1	Configure path
(config-trunk)#to 4.4.4.4	Configure the destination of rsvp trunk
(config-trunk)#commit	Commit the transaction.

RTR3

Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for loopback interface.
(config-if)#ip address 3.3.3.3/32 secondary	Configure IP address on loopback interface.
(config-if)#commit	Commit the transaction.

MPLS Interfaces

(config)#interface xe5	Enter the Interface mode
(config-if)#ip address 21.1.1.3/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe7	Enter the Interface mode
(config-if)#ip address 11.1.1.3/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce52	Enter the Interface mode
(config-if)#ip address 12.1.1.3/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#commit	Commit the transaction.

OSPF

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#router-id 3.3.3.3	Configure OSPF router id
(config-router)#network 3.3.3.3/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 11.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 12.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 21.1.1.0/24 area 0	Advertise network address in OSPF.
(config-if)#commit	Commit the transaction.

Global RSVP

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#commit	Commit the transaction.

RSVP Interface

(config)#interface xe5	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface

(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe7	Enter the Interface mode
(config-if)#enable-rsvp	Enable rsvp on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce52	Enter the Interface mode
(config-if)#enable-rsvp	Enable rsvp on the interface
(config-if)#commit	Commit the transaction.

Global SRLG (Path Type: Forced)

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#srlg-disjoint forced	Configure SRLG path type forced
(config-router)#commit	Commit the transaction.

When you use the one-to-one or facility backup protection, you must configure the `srlg-disjoint` type on all routers. When you use the secondary protection type, you only need to configure the `srlg-disjoint` type at the ingress node.de.

SRLG Interface

(config)#interface xe5	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 21	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe7	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 11	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce52	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 12	Configure SRLG value in the interface
(config-if)#commit	Commit the transaction.

RTR4

Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for loopback interface.
(config-if)#ip address 4.4.4.4/32 secondary	Configure IP address on the loopback address.
(config-if)#commit	Commit the transaction.

MPLS Interface

(config)#interface xe9	Enter the Interface mode
(config-if)#ip address 23.1.1.4/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface

(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce52	Enter the Interface mode
(config-if)#ip address 12.1.1.4/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce50	Enter the Interface mode
(config-if)#ip address 31.1.1.4/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#commit	Commit the transaction.

OSPF

(config)#router ospf 1	Enter Router OSPF mode.
(config-router)#router-id 4.4.4.4	Configure OSPF router id
(config-router)#network 4.4.4.4/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 12.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 23.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 31.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#commit	Commit the transaction.

Global RSVP

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#commit	Commit the transaction.

RSVP Interface

(config)#interface xe9	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce50	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce52	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#commit	Commit the transaction.

Global SRLG (Path Type: Forced)

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#srlg-disjoint forced	Configure SRLG path type forced
(config-router)#commit	Commit the transaction.

SRLG Interface

(config)#interface ce50	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 31	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce52	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 12	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe9	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 23	Configure SRLG value in the interface
(config-if)#commit	Commit the transaction.

RTR5

Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for loopback interface.
(config-if)#ip address 5.5.5.5/32 secondary	Configure IP address on the loopback address.
(config-if)#commit	Commit the transaction.

MPLS Interface

(config)#interface xe1	Enter the Interface mode
(config-if)#ip address 22.1.1.5/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe9	Enter the Interface mode
(config-if)#ip address 23.1.1.5/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe5	Enter the Interface mode
(config-if)#ip address 21.1.1.5/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#commit	Commit the transaction.

OSPF

(config)#router ospf 1	Enter Router OSPF mode.
(config-router)#router-id 5.5.5.5	Configure OSPF router id
(config-router)#network 5.5.5.5/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 21.1.1.0/24 area 0	Advertise network address in OSPF.

(config-router)#network 22.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 23.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#commit	Commit the transaction.

Global RSVP

(config)#router rsvp	Enter the Router RSVP mode.
(config)#commit	Commit the transaction.

RSVP Interface

(config)#interface xe1	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe5	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe9	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#commit	Commit the transaction.

Global SRLG (Path Type: Forced)

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#srlg-disjoint forced	Configure SRLG path type forced
(config-router)#commit	Commit the transaction.

SRLG Interface

(config)#interface xe1	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 11	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe5	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 21	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe9	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 23	Configure SRLG value in the interface
(config-if)#commit	Commit the transaction.

RTR6

Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for loopback interface.
(config-if)#ip address 6.6.6.6/32 secondary	Configure IP address on the loopback address.
(config-if)#commit	Commit the transaction.

MPLS Interface

(config)#interface xe5	Enter the Interface mode
(config-if)#ip address 30.1.1.6/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce50	Enter the Interface mode
(config-if)#ip address 31.1.1.6/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#commit	Commit the transaction.

OSPF

(config)#router ospf 1	Enter Router OSPF mode.
(config-router)#router-id 6.6.6.6	Configure OSPF router id
(config-router)#network 6.6.6.6/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 30.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 31.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#commit	Commit the transaction.

Global RSVP

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#commit	Commit the transaction.

RSVP Interface

(config)#interface xe5	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce50	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#commit	Commit the transaction.

Global SRLG (Path Type: Forced)

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#srlg-disjoint forced	Configure SRLG path type forced
(config-router)#commit	Commit the transaction.

SRLG Interface

(config)#interface xe5	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 30	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce50	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 31	Configure SRLG value in the interface
(config-if)#commit	Commit the transaction.

Validation**R1 Configuration (Ingress)****OSPF:**

```
RTR2#show ip ospf neighbor
Total number of full neighbors: 3
OSPF process 1 VRF(default):
Neighbor ID    Pri   State           Dead Time   Address        Interface       Instance ID
3.3.3.3        1    Full/DR         00:00:29    11.1.1.3       xe7             0
5.5.5.5        1    Full/DR         00:00:37    22.1.1.5       xe1             0
6.6.6.6        1    Full/DR         00:00:35    30.1.1.6       xe5             0
```

RSVP:

```
RTR2#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
```

```
Ingress RSVP:
To          From          Type    LSPName          State Uptime    Rt  Style  Labelin  Labelout  DSType
4.4.4.4     2.2.2.2       PRI     lsp1-Primary     UP    01:14:21  1 1 SE  -        24960     DEFAULT
4.4.4.4     2.2.2.2       SEC     lsp1-Secondary-Priority-1  UP    01:14:21  1 1 SE  -        24320     DEFAULT
4.4.4.4     2.2.2.2       PRI     lsp2-Primary     UP    01:03:18  1 1 SE  -        24961     DEFAULT
4.4.4.4     30.1.1.2      DTR     lsp2-Detour      UP    01:03:18  1 1 SE  -        24321     DEFAULT
4.4.4.4     2.2.2.2       BPS     bypass1-Bypass   UP    00:58:02  1 1 SE  -        24962     DEFAULT
4.4.4.4     2.2.2.2       PRI     lsp3-Primary     UP    00:57:26  1 1 SE  -        24321     DEFAULT
Total 6 displayed, Up 6, Down 0.
```

```
RTR2#show rsvp session detail
```

```
Ingress (Primary)
```

```
4.4.4.4
```

```
From: 2.2.2.2, LSPstate: Up, LSPname: lsp1-Primary
```

```
Ingress FSM state: Operational
```

```
Establishment Time: 0s 16ms
```

```
SRLG configured in primary path are: 11 12
```

```
Setup priority: 7, Hold priority: 0
```

CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
IGP-Shortcut: Disabled, LSP metric: 201
LSP Protection: None
Label in: -, Label out: 24960,
Tspec rate: 0, Fspec rate: 0
Policer: Not Configured
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 11.1.1.3, xe7
Path refresh: 30 seconds (RR enabled) (due in 25417 seconds)
Resv lifetime: 157 seconds (due in 133 seconds)
Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Configured Path: path1 (in use)
Configured Explicit Route Detail :
 11.1.1.3/32 strict
 12.1.1.4/32 strict
Session Explicit Route Detail :
 11.1.1.3/32 strict
 12.1.1.4/32 strict
Record route:

IP Address Label

 <self>
 11.1.1.3
 12.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
Ingress (Secondary-Priority1)
4.4.4.4
 From: 2.2.2.2, LSPstate: Up, LSPname: lsp1-Secondary-Priority-1
 Ingress FSM state: Operational
 Establishment Time: 0s 38ms
 SRLG configured in backup path are: 30 31
 SRLG-disjoint Configured: Forced
 Setup priority: 7, Hold priority: 0
 CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
 LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
 IGP-Shortcut: Disabled, LSP metric: 101
 LSP Protection: None
 Label in: -, Label out: 24320,

Tspec rate: 0, Fspec rate: 0
Policer: Not Configured
Tunnel Id: 5001, LSP Id: 2204, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 30.1.1.6, xe5
Path refresh: 30 seconds (RR enabled) (due in 25416 seconds)
Resv lifetime: 157 seconds (due in 127 seconds)
Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Configured Path: sec-path1 (in use)
Configured Explicit Route Detail :
 4.4.4.4/32 loose
Session Explicit Route Detail :
 30.1.1.6/32 strict
 31.1.1.4/32 strict
Record route:

IP Address Label

<self>
30.1.1.6
31.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
Ingress (Primary)
4.4.4.4
From: 2.2.2.2, LSPstate: Up, LSPname: lsp2-Primary
Ingress FSM state: Operational
Establishment Time: 0s 10ms
SRLG configured in primary path are: 11 12
Setup priority: 7, Hold priority: 0
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
IGP-Shortcut: Disabled, LSP metric: 201
LSP Protection: one-to-one
Fast-Reroute bandwidth : 0
Protection type desired: Link
Fast-Reroute Hop limit: 255
Fast-Reroute Setup priority: 7, Hold priority: 0
Label in: -, Label out: 24961,
Tspec rate: 0, Fspec rate: 0
Policer: Not Configured
Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2

```

Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 11.1.1.3, xe7
Path refresh: 30 seconds (RR enabled) (due in 26088 seconds)
Resv lifetime: 157 seconds (due in 133 seconds)
Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Configured Path: path1 (in use)
Configured Explicit Route Detail :
  11.1.1.3/32 strict
  12.1.1.4/32 strict
Session Explicit Route Detail :
  11.1.1.3/32 strict
  12.1.1.4/32 strict
Record route:
  LP = 1 -> PLR's Downstream link is protected      PU = 1 -> Protection is in use on
PLR
  NP = 1 -> PLR's Downstream neighbor is protected  BP = 1 -> BW protection available
at PLR
-----
IP Address          Label          (LP, PU, NP, BP)
-----
<self>
11.1.1.3              ( 1,  0,  0,  0)
12.1.1.4              ( 0,  0,  0,  0)
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
Ingress (Detour)
4.4.4.4
From: 30.1.1.2, LSPstate: Up, LSPname: lsp2-Detour
Ingress FSM state: Operational
Establishment Time: 0s 9ms
SRLG configured in backup path are: 30 31
SRLG-disjoint Configured: Forced
Setup priority: 7, Hold priority: 0
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
IGP-Shortcut: Disabled, LSP metric: 101
LSP Protection: None
Label in: -, Label out: 24321,
Tspec rate: 0, Fspec rate: 0
Policer: Not Configured
Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 30.1.1.6, xe5

```

Path refresh: 30 seconds (RR enabled) (due in 26073 seconds)
Resv lifetime: 157 seconds (due in 127 seconds)
Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Exclude path detail:
 Exclude Link: 11.1.1.3
Configured Path: none
Session Explicit Route Detail :
 30.1.1.6/32 strict
 31.1.1.4/32 strict
Record route:

IP Address Label

 <self>
 30.1.1.6
 31.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
Ingress (Bypass)
4.4.4.4
 From: 2.2.2.2, LSPstate: Up, LSPname: bypass1-Bypass
 Ingress FSM state: Operational
 Establishment Time: 0s 10ms
 SRLG configured in primary path are: 11 12
 Setup priority: 7, Hold priority: 0
 CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
 LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
 IGP-Shortcut: Disabled, LSP metric: 201
 LSP Protection: None
 Bypass trunk bandwidth type: Best-effort
 Label in: -, Label out: 24962,
 Tspec rate: 0, Fspec rate: 0
 Policer: Not Configured
 Tunnel Id: 5003, LSP Id: 2207, Ext-Tunnel Id: 2.2.2.2
 Bind value: 0, Oper state: NA, Alloc mode: NA
 Downstream: 11.1.1.3, xe7
 Path refresh: 30 seconds (RR enabled) (due in 26388 seconds)
 Resv lifetime: 157 seconds (due in 133 seconds)
 Retry count: 0, intrvl: 30 seconds
 RRO re-use as ERO: Disabled
 Label Recording: Disabled
 Admin Groups: none

```
Configured Path: path1 (in use)
Configured Explicit Route Detail :
  11.1.1.3/32 strict
  12.1.1.4/32 strict
Session Explicit Route Detail :
  11.1.1.3/32 strict
  12.1.1.4/32 strict
Record route:
-----
IP Address      Label
-----
<self>
11.1.1.3
12.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
Total LSP protected : 0, Bandwidth in use : 0
Ingress (Primary)
4.4.4.4
From: 2.2.2.2, LSPstate: Up, LSPname: lsp3-Primary
Ingress FSM state: Operational
Establishment Time: 0s 17ms
SRLG configured in primary path are: 11 23
Setup priority: 7, Hold priority: 0
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
IGP-Shortcut: Disabled, LSP metric: 2
LSP Protection: facility
Fast-Reroute bandwidth : 0
Protection type desired: Link
Fast-Reroute Hop limit: 255
Fast-Reroute Setup priority: 7, Hold priority: 0
Label in: -, Label out: 24321,
Tspec rate: 0, Fspec rate: 0
Policer: Not Configured
Tunnel Id: 5004, LSP Id: 2208, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 22.1.1.5, xel
Path refresh: 30 seconds (RR enabled) (due in 26421 seconds)
Resv lifetime: 157 seconds (due in 141 seconds)
Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Enabled
Admin Groups: none
Configured Path: sec-path1 (in use)
```

Configured Explicit Route Detail :

4.4.4.4/32 loose

Session Explicit Route Detail :

22.1.1.5/32 strict

23.1.1.4/32 strict

Record route:

LP = 1 -> PLR's Downstream link is protected PU = 1 -> Protection is in use on
PLR

NP = 1 -> PLR's Downstream neighbor is protected BP = 1 -> BW protection available
at PLR

```
-----
IP Address          Label      (LP, PU, NP, BP)
-----
```

<self>

22.1.1.5 24321 (0, 0, 0, 0)

23.1.1.4 0 (0, 0, 0, 0)

Style: Shared Explicit Filter

Traffic type: controlled-load

Minimum Path MTU: 1500

Last Recorded Error Code: None

Last Recorded Error Value: None

Node where Last Recorded Error originated: None

Trunk Type: mpls

CSPF LSP:

RTR2#show cspf lsp

Lsp Id : 0x13890899

OSPF ID : 1

Ingress : 2.2.2.2

Egress : 4.4.4.4

Ext Tunnel ID : 2.2.2.2

LSP Type : 0

Client ID : 1

State : 3

Setup Priority : 7

Hold Priority : 0

Hop Limit : 255

Include Mask : 0x0

Exclude Mask : 0x0

Include All Mask: 0x0

LSP Metric : 201

Path Constraint :

11.1.1.3 strict

12.1.1.4 strict

Computed ERO :

11.1.1.3

12.1.1.4

SRLG values of LSP :

11 12

Lsp Id : 0x1389089c
OSPF ID : 1
Ingress : 2.2.2.2
Egress : 4.4.4.4
Ext Tunnel ID : 2.2.2.2
LSP Type : 0
Client ID : 1
State : 3
Setup Priority : 7
Hold Priority : 0
Hop Limit : 255
Include Mask : 0x0
Exclude Mask : 0x0
Include All Mask: 0x0
LSP Metric : 101
Path Constraint :
 4.4.4.4 loose
Exclude SRLG Constraint :
11 12
Computed ERO :
 30.1.1.6
 31.1.1.4

SRLG values of LSP :

30 31
Lsp Id : 0x138a089e
OSPF ID : 1
Ingress : 2.2.2.2
Egress : 4.4.4.4
Ext Tunnel ID : 2.2.2.2
LSP Type : 0
Client ID : 1
State : 3
Setup Priority : 7
Hold Priority : 0
Hop Limit : 255
Include Mask : 0x0
Exclude Mask : 0x0
Include All Mask: 0x0
LSP Metric : 201
Path Constraint :
 11.1.1.3 strict
 12.1.1.4 strict
Computed ERO :
 11.1.1.3
 12.1.1.4

SRLG values of LSP :

11 12
Lsp Id : 0x138a089e

```
OSPF ID      : 1
Ingress      : 30.1.1.2
Egress       : 4.4.4.4
Ext Tunnel ID : 2.2.2.2
LSP Type     : 0
Client ID    : 1
State        : 3
Setup Priority : 7
Hold Priority : 0
Hop Limit    : 255
Include Mask  : 0x0
Exclude Mask  : 0x0
Include All Mask: 0x0
LSP Metric   : 101
Exclude Path Constraint :
    11.1.1.3    exclude link
Exclude SRLG Constraint :
11
Computed ERO :
    30.1.1.6
    31.1.1.4
```

SRLG values of LSP :

```
30    31
Lsp Id      : 0x138b089f
OSPF ID     : 1
Ingress     : 2.2.2.2
Egress      : 4.4.4.4
Ext Tunnel ID : 2.2.2.2
LSP Type    : 2
Client ID   : 1
State       : 3
Setup Priority : 7
Hold Priority : 0
Hop Limit   : 255
Include Mask : 0x0
Exclude Mask : 0x0
Include All Mask: 0x0
LSP Metric  : 201
Path Constraint :
    11.1.1.3    strict
    12.1.1.4    strict
Computed ERO :
    11.1.1.3
    12.1.1.4
```

SRLG values of LSP :

```
11    12
Lsp Id      : 0x138c08a0
OSPF ID     : 1
```

Ingress : 2.2.2.2
Egress : 4.4.4.4
Ext Tunnel ID : 2.2.2.2
LSP Type : 0
Client ID : 1
State : 3
Setup Priority : 7
Hold Priority : 0
Hop Limit : 255
Include Mask : 0x0
Exclude Mask : 0x0
Include All Mask: 0x0
LSP Metric : 2
Path Constraint :
 4.4.4.4 loose
Computed ERO :
 22.1.1.5
 23.1.1.4

SRLG values of LSP :
11 23

RTR3 Configuration (Transit)

OSPF:

RTR3#show ip ospf neighbor

Total number of full neighbors: 3
OSPF process 1 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
2.2.2.2	1	Full/Backup	00:00:32	11.1.1.2	xe7	0
4.4.4.4	1	Full/Backup	00:00:32	12.1.1.4	ce52	0
5.5.5.5	1	Full/Backup	00:00:36	21.1.1.5	xe5	0

RSVP:

RTR3#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:

To	From	Type	LSPName	State	Uptime	Rt	Style	Labelin	Labelout	DSType
4.4.4.4	21.1.1.3	DTR	lsp2-Detour	UP	01:12:50	1 1	SE	-	24320	ELSP_CON

Total 1 displayed, Up 1, Down 0.

Transit RSVP:

To	From	Type	LSPName	State	Uptime	Rt	Style	Labelin	Labelout	DSType
4.4.4.4	2.2.2.2	PRI	lsp1-Primary	UP	01:23:54	1 1	SE	24960	0	ELSP_CON
4.4.4.4	2.2.2.2	PRI	lsp2-Primary	UP	01:12:50	1 1	SE	24961	0	ELSP_CON
4.4.4.4	2.2.2.2	PRI	bypass1-Bypass	UP	01:07:35	1 1	SE	24962	0	ELSP_CON

Total 3 displayed, Up 3, Down 0.

RTR3#show rsvp session detail
Transit

4.4.4.4

From: 2.2.2.2, LSPstate: Up, LSPname: lsp1-Primary
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 24960, Label out: 0,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 12.1.1.4, ce52 Upstream: 11.1.1.2, xe7
Path refresh: 30 seconds (RR enabled) (due in 24976 seconds)
Path lifetime: 157 seconds (due in 112 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 32606 seconds)
Resv lifetime: 157 seconds (due in 143 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
11.1.1.3/32 strict
12.1.1.4/32 strict
Session Explicit Route Detail :
12.1.1.4/32 strict
Record route:

IP Address Label

11.1.1.2
<self>
12.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls

Transit

4.4.4.4

From: 2.2.2.2, LSPstate: Up, LSPname: lsp2-Primary
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: one-to-one
Fast-Reroute bandwidth : 0
Protection type desired: Link
Fast-Reroute Hop limit: 255
Fast-Reroute Setup priority: 7, Hold priority: 0
Label in: 24961, Label out: 0,

Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 12.1.1.4, ce52 Upstream: 11.1.1.2, xe7
Path refresh: 30 seconds (RR enabled) (due in 25624 seconds)
Path lifetime: 157 seconds (due in 112 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 24416 seconds)
Resv lifetime: 157 seconds (due in 143 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
 11.1.1.3/32 strict
 12.1.1.4/32 strict
Session Explicit Route Detail :
 12.1.1.4/32 strict
Record route:

IP Address Label

11.1.1.2
<self>
12.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
Ingress (Detour)
4.4.4.4
From: 21.1.1.3, LSPstate: Up, LSPname: lsp2-Detour
Ingress FSM state: Operational
Establishment Time: 0s 8ms
SRLG configured in backup path are: 21 23
Setup priority: 7, Hold priority: 0
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
IGP-Shortcut: Disabled, LSP metric: 2
LSP Protection: None
Label in: -, Label out: 24320,
Tspec rate: 0, Fspec rate: 0
Policer: Not Configured
Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 21.1.1.5, xe5
Path refresh: 30 seconds (RR enabled) (due in 25636 seconds)
Resv lifetime: 157 seconds (due in 153 seconds)

Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Exclude path detail:
 Exclude Link: 11.1.1.2
 Exclude Link: 12.1.1.4
Configured Path: none
Session Explicit Route Detail :
 21.1.1.5/32 strict
 23.1.1.4/32 strict
Record route:

IP Address Label

<self>
21.1.1.5
23.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
Transit
4.4.4.4
From: 2.2.2.2, LSPstate: Up, LSPname: bypass1-Bypass
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 24962, Label out: 0,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5003, LSP Id: 2207, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 12.1.1.4, ce52 Upstream: 11.1.1.2, xe7
Path refresh: 30 seconds (RR enabled) (due in 25940 seconds)
Path lifetime: 157 seconds (due in 112 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 27142 seconds)
Resv lifetime: 157 seconds (due in 143 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
 11.1.1.3/32 strict
 12.1.1.4/32 strict
Session Explicit Route Detail :
 12.1.1.4/32 strict

Record route:

```
-----
IP Address      Label
-----
11.1.1.2
<self>
12.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type:  ELSP_CONFIG
CLASS      DSCP_value      EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
```

RTR4 Configuration (Egress)

OSPF:

```
RTR4#show ip ospf neighbor

Total number of full neighbors: 3
OSPF process 1 VRF(default):
Neighbor ID      Pri  State           Dead Time   Address      Interface     Instance ID
3.3.3.3          1   Full/DR         00:00:27    12.1.1.3     ce52          0
5.5.5.5          1   Full/Backup     00:00:27    23.1.1.5     xe9           0
6.6.6.6          1   Full/Backup     00:00:34    31.1.1.6     ce50          0
```

RSVP:

```
RTR4#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
```

```
Egress RSVP:
To      From      Type      LSPName      State Uptime   Rt  Style  Labelin  Labelout  DStype
4.4.4.4 2.2.2.2    PRI      lsp1-Primary  UP    01:28:26  1 1 SE   0        -         ELSP_CON
4.4.4.4 2.2.2.2    PRI      lsp1-Secondary-Priority-1  UP    01:28:26  1 1 SE   0        -         ELSP_CON
4.4.4.4 2.2.2.2    PRI      lsp2-Primary  UP    01:17:22  1 1 SE   0        -         ELSP_CON
4.4.4.4 30.1.1.2   PRI      lsp2-Detour   UP    01:17:22  1 1 SE   0        -         ELSP_CON
4.4.4.4 21.1.1.3   PRI      lsp2-Detour   UP    01:17:22  1 1 SE   0        -         ELSP_CON
4.4.4.4 2.2.2.2    PRI      bypass1-Bypass  UP    01:12:07  1 1 SE   0        -         ELSP_CON
4.4.4.4 2.2.2.2    PRI      lsp3-Primary  UP    01:11:31  1 1 SE   0        -         ELSP_CON
Total 7 displayed, Up 7, Down 0.
```

```
RTR4#show rsvp session detail
Egress
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: lsp1-Primary
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:      0, Label out: -,
  Tspec rate: 0, Fspec rate: 0
```

Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 12.1.1.3, ce52
Path lifetime: 157 seconds (due in 141 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 39085 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
12.1.1.4/32 strict
Record route:

```
-----  
IP Address      Label  
-----
```

11.1.1.2

12.1.1.3

<self>

Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls

Egress

4.4.4.4

From: 2.2.2.2, LSPstate: Up, LSPname: lsp1-Secondary-Priority-1
Egress FSM state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 0, Label out: -,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5001, LSP Id: 2204, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 31.1.1.6, ce50
Path lifetime: 157 seconds (due in 141 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 9957 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
31.1.1.4/32 strict
Record route:

```
-----  
IP Address      Label  
-----
```

30.1.1.2

31.1.1.6

<self>

Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls

Egress

4.4.4.4

From: 2.2.2.2, LSPstate: Up, LSPname: lsp2-Primary
Egress FSM state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: one-to-one
Fast-Reroute bandwidth : 0
Protection type desired: Link
Fast-Reroute Hop limit: 255
Fast-Reroute Setup priority: 7, Hold priority: 0
Label in: 0, Label out: -,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 12.1.1.3, ce52
Path lifetime: 157 seconds (due in 141 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 33578 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
12.1.1.4/32 strict
Record route:

IP Address Label

11.1.1.2

12.1.1.3

<self>

Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls

Egress

4.4.4.4

From: 30.1.1.2, LSPstate: Up, LSPname: lsp2-Detour

Egress FSM state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 0, Label out: -,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 31.1.1.6, ce50
Path lifetime: 157 seconds (due in 141 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 27672 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
31.1.1.4/32 strict
Record route:

IP Address Label

30.1.1.2
31.1.1.6
<self>

Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls

Egress

4.4.4.4

From: 21.1.1.3, LSPstate: Up, LSPname: lsp2-Detour
Egress FSM state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 0, Label out: -,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 23.1.1.5, xe9
Path lifetime: 157 seconds (due in 133 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 17352 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
23.1.1.4/32 strict
Record route:

```
-----
IP Address      Label
-----
21.1.1.3
23.1.1.5
<self>
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type:  ELSP_CONFIG
CLASS      DSCP_value      EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
Egress
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: bypass1-Bypass
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:      0, Label out: -,
  Tspecc rate: 0, Fspec rate: 0
  Tunnel Id: 5003, LSP Id: 2207, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Upstream: 12.1.1.3, ce52
  Path lifetime: 157 seconds (due in 141 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 22891 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:  Received Explicit Route Detail :
    12.1.1.4/32 strict
  Record route:
  -----
  IP Address      Label
  -----
  11.1.1.2
  12.1.1.3
  <self>
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS      DSCP_value      EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Egress
```

4.4.4.4

```

From: 2.2.2.2, LSPstate: Up, LSPname: lsp3-Primary
Egress FSM state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: facility
Fast-Reroute bandwidth : 0
Protection type desired: Link
Fast-Reroute Hop limit: 255
Fast-Reroute Setup priority: 7, Hold priority: 0
Label in:      0, Label out: -,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5004, LSP Id: 2208, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 23.1.1.5, xe9
Path lifetime: 157 seconds (due in 133 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 33344 seconds)
RRO re-use as ERO: Disabled
Label Recording: Enabled
Admin Groups:   Received Explicit Route Detail :
  23.1.1.4/32 strict
Record route:
-----
IP Address      Label
-----
22.1.1.2        24321
23.1.1.5        0
<self>
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type:  ELSP_CONFIG
CLASS      DSCP_value  EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls

```

RTR5 Configuration**OSPF:**

```
RTR5#show ip ospf neighbor
```

```
Total number of full neighbors: 3
```

```
OSPF process 1 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
3.3.3.3	1	Full/DR	00:00:34	21.1.1.3	xe5	0
2.2.2.2	1	Full/Backup	00:00:30	22.1.1.2	xe1	0
4.4.4.4	1	Full/DR	00:00:39	23.1.1.4	xe9	0

RSVP:

```
RTR5#show rsvp session
```

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
 State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
 * indicates the session is active with local repair at one or more nodes
 (P) indicates the secondary-priority session is acting as primary

Transit RSVP:

To	From	Type	LSPName	State	Uptime	Rt	Style	Labelin	Labelout	DSType
4.4.4.4	21.1.1.3	PRI	lsp2-Detour	UP	01:23:45	1 1	SE	24320	0	ELSP_CON
4.4.4.4	2.2.2.2	PRI	lsp3-Primary	UP	01:17:54	1 1	SE	24321	0	ELSP_CON

Total 2 displayed, Up 2, Down 0.

RTR5#show rsvp session detail

Transit

4.4.4.4

From: 21.1.1.3, LSPstate: Up, LSPname: lsp2-Detour
 Transit upstream state: Operational, downstream state: Operational
 Setup priority: 7, Hold priority: 0
 IGP-Shortcut: Disabled, LSP metric: 65
 LSP Protection: None
 Label in: 24320, Label out: 0,
 Tspec rate: 0, Fspec rate: 0
 Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
 Bind value: 0, Oper state: NA, Alloc mode: NA
 Downstream: 23.1.1.4, xe9 Upstream: 21.1.1.3, xe5
 Path refresh: 30 seconds (RR enabled) (due in 24907 seconds)
 Path lifetime: 157 seconds (due in 126 seconds)
 Resv refresh: 30 seconds (RR enabled) (due in 36355 seconds)
 Resv lifetime: 157 seconds (due in 144 seconds)
 RRO re-use as ERO: Disabled
 Label Recording: Disabled
 Admin Groups: Received Explicit Route Detail :
 21.1.1.5/32 strict
 23.1.1.4/32 strict
 Session Explicit Route Detail :
 23.1.1.4/32 strict
 Record route:

 IP Address Label

21.1.1.3

<self>

23.1.1.4

Style: Shared Explicit Filter
 Traffic type: controlled-load
 Minimum Path MTU: 1500
 LSP Type: ELSP_CONFIG
 CLASS DSCP_value EXP_value
 Last Recorded Error Code: None
 Last Recorded Error Value: None
 Node where Last Recorded Error originated: None
 Trunk Type: mpls

Transit

4.4.4.4

```
From: 2.2.2.2, LSPstate: Up, LSPname: lsp3-Primary
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: facility
Fast-Reroute bandwidth : 0
Protection type desired: Link
Fast-Reroute Hop limit: 255
Fast-Reroute Setup priority: 7, Hold priority: 0
Label in: 24321, Label out: 0,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5004, LSP Id: 2208, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 23.1.1.4, xe9 Upstream: 22.1.1.2, xe1
Path refresh: 30 seconds (RR enabled) (due in 25271 seconds)
Path lifetime: 157 seconds (due in 148 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 38338 seconds)
Resv lifetime: 157 seconds (due in 144 seconds)
RRO re-use as ERO: Disabled
Label Recording: Enabled
Admin Groups: Received Explicit Route Detail :
  22.1.1.5/32 strict
  23.1.1.4/32 strict
Session Explicit Route Detail :
  23.1.1.4/32 strict
Record route:
-----
IP Address      Label
-----
22.1.1.2        24321
<self>
23.1.1.4        0
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS    DSCP_value    EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
```

RTR6 Configuration

OSPF:

```
RTR6#show ip ospf neighbor
Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID    Pri  State      Dead Time  Address      Interface    Instance ID
2.2.2.2        1    Full/Backup 00:00:32   30.1.1.2     xe5          0
4.4.4.4        1    Full/DR     00:00:38   31.1.1.4     ce50         0
```


RSVP:

```
RTR6#show rsvp session
```

```
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
```

```
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
```

```
* indicates the session is active with local repair at one or more nodes
```

```
(P) indicates the secondary-priority session is acting as primary
```

```
Transit RSVP:
```

To	From	Type	LSPName	State	Uptime	Rt	Style	Labelin	Labelout	DSType
4.4.4.4	2.2.2.2	PRI	lsp1-Secondary-Priority-1	UP	01:38:16	1 1	SE	24320	0	ELSP_CON
4.4.4.4	30.1.1.2	PRI	lsp2-Detour	UP	01:27:12	1 1	SE	24321	0	ELSP_CON

Total 2 displayed, Up 2, Down 0.

```
RTR6#show rsvp session detail
```

```
Transit
```

```
4.4.4.4
```

```
From: 2.2.2.2, LSPstate: Up, LSPname: lsp1-Secondary-Priority-1
```

```
Transit upstream state: Operational, downstream state: Operational
```

```
Setup priority: 7, Hold priority: 0
```

```
IGP-Shortcut: Disabled, LSP metric: 65
```

```
LSP Protection: None
```

```
Label in: 24320, Label out: 0,
```

```
Tspec rate: 0, Fspec rate: 0
```

```
Tunnel Id: 5001, LSP Id: 2204, Ext-Tunnel Id: 2.2.2.2
```

```
Bind value: 0, Oper state: NA, Alloc mode: NA
```

```
Downstream: 31.1.1.4, ce50 Upstream: 30.1.1.2, xe5
```

```
Path refresh: 30 seconds (RR enabled) (due in 24080 seconds)
```

```
Path lifetime: 157 seconds (due in 149 seconds)
```

```
Resv refresh: 30 seconds (RR enabled) (due in 37411 seconds)
```

```
Resv lifetime: 157 seconds (due in 150 seconds)
```

```
RRO re-use as ERO: Disabled
```

```
Label Recording: Disabled
```

```
Admin Groups: Received Explicit Route Detail :
```

```
30.1.1.6/32 strict
```

```
31.1.1.4/32 strict
```

```
Session Explicit Route Detail :
```

```
31.1.1.4/32 strict
```

```
Record route:
```

```
-----  
IP Address      Label  
-----
```

```
30.1.1.2
```

```
<self>
```

```
31.1.1.4
```

```
Style: Shared Explicit Filter
```

```
Traffic type: controlled-load
```

```
Minimum Path MTU: 1500
```

```
LSP Type: ELSP_CONFIG
```

```
CLASS      DSCP_value      EXP_value
```

```
Last Recorded Error Code: None
```

```
Last Recorded Error Value: None
```

```
Node where Last Recorded Error originated: None
```

Trunk Type: mpls
Transit
4.4.4.4
From: 30.1.1.2, LSPstate: Up, LSPname: lsp2-Detour
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 24321, Label out: 0,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 31.1.1.4, ce50 Upstream: 30.1.1.2, xe5
Path refresh: 30 seconds (RR enabled) (due in 24724 seconds)
Path lifetime: 157 seconds (due in 149 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 32187 seconds)
Resv lifetime: 157 seconds (due in 150 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
30.1.1.6/32 strict
31.1.1.4/32 strict
Session Explicit Route Detail :
31.1.1.4/32 strict
Record route:

IP Address Label

30.1.1.2
<self>
31.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls

CHAPTER 5 MPLS DiffServ Configuration

This chapter contains an overview of MPLS DiffServ functionality and terminology, MPLS DiffServ configuration example for a relevant scenario, configuration guidelines, and sample procedures for enabling and configuring MPLS DiffServ.

MPLS Diff-Serv Overview

The initial efforts to provide quality of service (QoS) in IP networks were based on a per application-Flow model (IntServ), in which individual applications requested QoS. With large number of flows traversing IP networks, this approach proved to be un-scalable and overly complex, and a more “coarse-grained” model was developed in the form of DiffServ. DiffServ approaches the problem of QoS by dividing traffic into a small number of classes and allocating network resources on a per-class basis. DiffServ provides differential forwarding treatment to traffic, thus enforcing QoS for different traffic flows. It is a scalable solution that does not require per flow signalling and state maintenance in the core. However, it cannot guarantee QoS if the path followed by the traffic does not have adequate resources to meet the QoS requirements.

DiffServ Tunnelling modes:

RFC 3270 has recommended three QoS models for DiffServ tunnelled traffic in MPLS networks:

OcNOS supports two models:

- Pipe model (default mode): With the Pipe Model, MPLS tunnels (aka LSPs) are used to hide the intermediate MPLS nodes between LSP Ingress and Egress from the Diff-Serv perspective. In this model, tunneled packets must convey two meaningful pieces of Diff-Serv information:
 - The Diff-Serv information which is meaningful to intermediate nodes along the LSP span including the LSP Egress (which we refer to as the “LSP Diff-Serv Information”). This LSP Diff-Serv Information is not meaningful beyond the LSP Egress: Whether Traffic Conditioning at intermediate nodes on the LSP span affects the LSP Diff-Serv information or not, this updated Diff-Serv information is not considered meaningful beyond the LSP Egress and is ignored.
 - The Diff-Serv information which is meaningful beyond the LSP Egress (which we refer to as the “Tunneled Diff-Serv Information”). This information is to be conveyed by the LSP Ingress to the LSP Egress. This Diff-Serv information is not meaningful to the intermediate nodes on the LSP span.
- Uniform model: With the Uniform Model, MPLS tunnels (aka LSPs) are viewed as artifacts of the end-to-end path from the Diff-Serv standpoint. MPLS Tunnels may be used for forwarding purposes but have no significant impact on Diff-Serv. In this model, any packet contains exactly one piece of Diff-Serv information which is meaningful and is always encoded in the outer most label entry (or in the IP DSCP where the IP packet is transmitted unlabeled for instance at the egress of the LSP). Any Diff-Serv information encoded somewhere else (e.g., in deeper label entries) is of no significance to intermediate nodes or to the tunnel egress and is ignored. If Traffic Conditioning at intermediate nodes on the LSP span affects the “outer” Diff-Serv information, the updated Diff-Serv information is the one considered meaningful at the egress of the LSP.
 - The Uniform Model for Diff-Serv over MPLS is such that, from the Diff-Serv perspective, operations are exactly identical to the operations if MPLS was not used. In other words, MPLS is entirely transparent to the Diff-Serv operations.
 - Use of the Uniform Model allows LSPs to span Diff-Serv domain boundaries without any other measure in place than an inter-domain Traffic Conditioning Agreement at the physical boundary between the Diff-Serv domains and operating exclusively on the “outer” header, since the meaningful Diff-Serv information is always visible and modifiable in the outmost label entry.

Terminology

Following is a brief description of terms and concepts used to describe MPLS Diffserv.

EXP Value

The MPLS experimental bits (EXP) field is a 3-bit field in the MPLS header that you can use to define the QoS treatment (per-hop behavior) that a node should give to a packet. In an IP network, the DiffServ Code Point (DSCP) (a 6-bit field) defines a class and drop precedence. The EXP bits can be used to carry some of the information encoded in the IP DSCP and can also be used to encode the dropping precedence.

By default, OcNOS copies the three most significant bits of the DSCP or the IP precedence of the IP packet to the EXP field in the MPLS header. This action happens when the MPLS header is initially imposed on the IP packet. However, you can also set the EXP field by defining a mapping between the DSCP or IP precedence and the EXP bits. This mapping is configured using the `set mpls class` command in `pmap-class` mode or `qos map class exp` in global mode. For more information, see the “Remarking” section.

DSCP Value

Differentiated Services Code Point (DSCP) is a 6-bit value used to classify the priority of Layer-3 packets upon entry into a network. DSCP values range from 0 to 63, 63 being the highest priority, 0 being best-effort traffic.

Classification

Traffic classification allows the network to recognize traffic as it falls into classes that you have configured. Network traffic must be classified to apply specific QoS to it. Classification can be inclusive (for example, all of the traffic passing through an interface) or classification can be very specific (for example, you can use a class map with match commands that recognize specific aspects of the traffic). You can classify and apply QoS (for example, marking) and then, on another interface or network device, classify again based on the marked value and apply other QoS.

Policing

Policing determines whether a packet is in or out of profile by comparing the internal DSCP to the configured policer. Policer limits the bandwidth consumed by a traffic flow with the results given to the marker.

Policing and policers have the following attributes:

- Policers can occur only on a physical port basis.
- Policing can occur on ingress interfaces.
- Only one policer can be applied to a packet per direction.

Marking

Marking determines how to handle a packet when it is out of profile. It assesses the policer and the configuration data to determine the action required for the packet, and then handles the packet using one of the following methods:

- Let the packet through without modification
- Drop the packet

Marking can occur on ingress and egress interfaces.

Class Map

A class map names and isolates specific traffic from other traffic. The class map defines the criteria used to match against a specific traffic flow to classify it further. The criteria can include:

- Matching the access group defined by the ACL
- Matching a specific list of DSCP values

If there is more than one type of traffic to be classified, another class map can be created under a different name. After a packet is matched against the class-map criteria, it is further classified using a policy map.

Policy Map

A policy map specifies on which traffic class to act. This can be implemented as follows:

- Set a specific CoS or DSCP value in the traffic class.
- Specify the traffic bandwidth limitations for each matched traffic class (policer) and the action to take (marking) when the traffic is out of profile.

Policy maps have the following attributes:

- A policy map can contain multiple class statements, each with different match criteria and policers.
- A separate policy-map class can exist for each type of traffic received through an interface.
- There can be only one policy map per interface per direction. The same policy map can be applied to multiple interfaces and directions.
- Before a policy map can be effective, it must be attached to an interface.

MPLS Class

MPLS class or class specifies the class of the frames, for example frames with DSCP 0-7 belongs to class 0, DSCP 8-15 belongs to Class 1, and so on.

In OcNOS, there are 8 classes varying from 0-7. By default, EXP to class is mapped one-to-one.

For more, see [Table 5-1](#)

For MPLS Diff-Serv to work, QoS must be enabled at the global level. By default QoS is disabled.

Table 5-1: EXP to class mapping

CoS	DSCP	EXP	Class	Queue
0	0-7	0	0	0
1	8-15	1	1	1
2	16-23	2	2	2
3	24-31	3	3	3
4	32-39	4	4	4
5	40-47	5	5	5
6	48-55	6	6	6
7	56-63	7	7	7

CHAPTER 6 Remarking Configuration

This chapter contains a complete sample of configuring marking on global level and remarking of EXP bits on interface and global level along with LDP LSP for Pipe model and Uniform model.

Configuration

Configuring Remarking for MPLS EXP bits require following configurations:

- Enabling label-switching on the interface on NSM.
- Configuring LSP (Using LDP, Static or RSVP-TE, in this example we are using LDP for setting up LSP).
- Running an IGP (Internal Gateway Protocol), for example, OSPF, to distribute reachability information within the MPLS cloud.
- Enable QoS, Configuring Remarking on interface and Global Level.

Topology

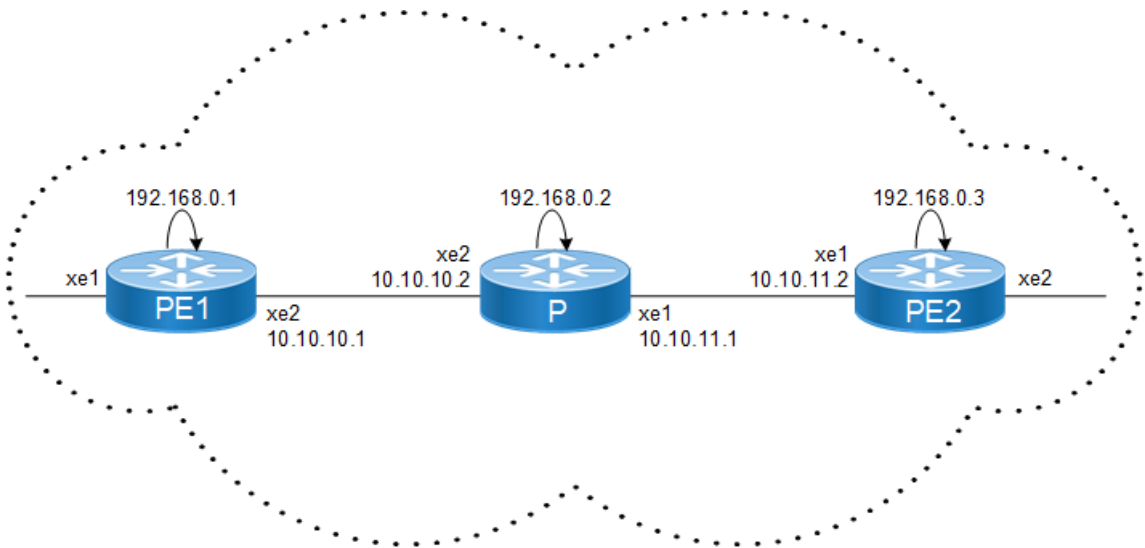


Figure 6-2: Basic LDP Topology

OSPF and LDP Configuration for PE1, P and PE2

PE1: NSM

#configure terminal	Enter configure mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#ip address 10.10.10.1/24	Configure IP address for the interface
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.

(config-if)#ip address 192.168.0.1/32 secondary	Set the IP address of the loopback interface to 192.168.0.1/32
(config-if)#commit	Commit the transaction.

PE1: OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.10.10.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 192.168.0.1/32 area 0	
(config-router)#commit	Commit the transaction.

PE1: LDP

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 192.168.0.1	Set the router ID to IP address 192.168.0.1.
(config-router)#transport-address ipv4 192.168.0.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe1.
(config-if)#commit	Commit the transaction.

P: NSM

#configure terminal	Enter configure mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#ip address 10.10.10.2/24	Configure IP address for the interface
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.10.11.1/24	Configure IP address for the interface
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 192.168.0.2/32 secondary	Set the IP address of the loopback interface to 192.168.0.2/32
(config-if)#commit	Commit the transaction.

P: OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.10.10.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.10.11.0/24 area 0	
(config-router)#network 192.168.0.2/32 area 0	
(config-router)#commit	Commit the transaction.

P: LDP

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 192.168.0.2	Set the router ID to IP address 192.168.0.2.
(config-router)#transport-address ipv4 192.168.0.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#commit	Commit the transaction.

PE2: NSM

#configure terminal	Enter configure mode.
(config)#interface xe1	Specify the interface (xe2) to be configured.
(config-if)#ip address 10.10.11.2/24	Configure IP address for the interface
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 192.168.0.3/32 secondary	Set the IP address of the loopback interface to 192.168.0.3/32
(config-if)#commit	Commit the transaction.

PE2: OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.10.11.0/24 area 0 (config-router)#network 192.168.0.3/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

PE2: LDP

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 192.168.0.3	Set the router ID to IP address 192.168.0.3.
(config-router)#explicit-null	To disable PHP.
(config-router)#transport-address ipv4 192.168.0.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#commit	Commit the transaction.

Configuration of Marking or Remarking

Marking can be done in Global level and Remarking can be done in Global level and in Interface level. Both methods are shown in the following sample configurations.

Global level configuration for PE1

#configure terminal	Enter configure mode.
(config)#qos enable	Enable QOS.
(config)#qos profile exp-encap default	Configure default profile.
(config-egress-exp-encap-map)#13 dscp 10 exp 3	Map dscp value 10 to exp 3.
(config-egress-exp-encap-map)#commit	Commit the transaction.

Validation

```
PE1#show qos-profile type exp-encap default
profile name: default
```

```

profile type: exp-encap
configured mapping:
qos profile exp-encap default
 13 dscp 10 exp 3
!
    
```

Detailed mapping:

L3 DSCP to EXP

INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT
DSCP	EXP	DSCP	EXP	DSCP	EXP	DSCP	EXP
0	0	16	2	32	4	48	6
1	0	17	2	33	4	49	6
2	0	18	2	34	4	50	6
3	0	19	2	35	4	51	6
4	0	20	2	36	4	52	6
5	0	21	2	37	4	53	6
6	0	22	2	38	4	54	6
7	0	23	2	39	4	55	6
8	1	24	3	40	5	56	7
9	1	25	3	41	5	57	7
10	3	26	3	42	5	58	7
11	1	27	3	43	5	59	7
12	1	28	3	44	5	60	7
13	1	29	3	45	5	61	7
14	1	30	3	46	5	62	7
15	1	31	3	47	5	63	7

L2 Queue + Color to EXP

INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT
Queue	Color	Queue	Color	Queue	Color
0	green	0	yellow	0	red
1	green	1	yellow	1	red
2	green	2	yellow	2	red
3	green	3	yellow	3	red
4	green	4	yellow	4	red
5	green	5	yellow	5	red
6	green	6	yellow	6	red
7	green	7	yellow	7	red

Interface level configuration for PE1

#configure terminal	Enter configure mode.
(config)#qos enable	Enable QOS.
(config)#qos profile exp-encap TEST1	Configure non-default profile.
(config-egress-exp-encap-map)#13 dscp 5 exp 5	Map dscp value 5 to exp 5.

(config-egress-exp-encap-map) #exit	Exit exp-encap profile mode.
(config) #interface xe2	Enter interface mode.
(config-if) #qos map-profile exp-encap TEST1	Mapping qos profile to interface
(config-if) #commit	Commit the transaction.

Validation

```

PE1#show qos-profile type exp-encap TEST1
profile name: TEST1
profile type: exp-encap
profile attached to 1 instances
configured mapping:
 13 dscp 5 exp 5
Detailed mapping:
L3 DSCP to EXP

```

INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT
DSCP	EXP	DSCP	EXP	DSCP	EXP	DSCP	EXP
0	0	16	2	32	4	48	6
1	0	17	2	33	4	49	6
2	0	18	2	34	4	50	6
3	0	19	2	35	4	51	6
4	0	20	2	36	4	52	6
5	5	21	2	37	4	53	6
6	0	22	2	38	4	54	6
7	0	23	2	39	4	55	6
8	1	24	3	40	5	56	7
9	1	25	3	41	5	57	7
10	1	26	3	42	5	58	7
11	1	27	3	43	5	59	7
12	1	28	3	44	5	60	7
13	1	29	3	45	5	61	7
14	1	30	3	46	5	62	7
15	1	31	3	47	5	63	7

L2 Queue + Color to EXP

INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT
Queue	Color	Queue	Color	Queue	Color
0	green	0	yellow	0	red
1	green	1	yellow	1	red
2	green	2	yellow	2	red
3	green	3	yellow	3	red
4	green	4	yellow	4	red
5	green	5	yellow	5	red
6	green	6	yellow	6	red
7	green	7	yellow	7	red

Global level configuration for PE2

#configure terminal	Enter configure mode.
(config)#qos enable	Enable QOS.
(config)#qos statistics	Enable QOS statistics.
(config)#qos profile exp-to-queue default	Configure default profile
(config-ingress-exp-queue-map)#exp 5 queue 7	Map exp value 5 to Class 7.
(config-ingress-exp-queue-map)#commit	Commit the transaction.

Validation

PE2

```
PE2#show qos-profile type exp-to-queue
```

```
profile name: default
profile type: exp-to-queue
configured mapping:
qos profile exp-to-queue default
  exp 5 queue 7
!
```

```
Detailed mapping:
```

-----+-----		
INPUT	OUTPUT	
-----+-----		
EXP	Queue	Color
-----+-----		
0	0	green
1	1	green
2	2	green
3	3	green
4	4	green
5	7	green
6	6	green
7	7	green

PE1

```
PE1#show qos-profile interface xe2
profile name: default
profile type: dscp-to-queue (Ingress)
mapping:
```

-----+-----			
-----+-----			
INPUT	OUTPUT	INPUT	OUTPUT
INPUT	OUTPUT	INPUT	OUTPUT
-----+-----			
DSCP	TC	Color	Out DSCP
DSCP	TC	Color	Out DSCP

TC	Color	Out DSCP
0	0	green
32	4	green
	green	48
1	0	green
33	4	green
	green	49
2	0	green
34	4	green
	green	50
3	0	green
35	4	green
	green	51
4	0	green
36	4	yellow
	green	52
5	0	green
37	4	green
	green	53
6	0	green
38	4	yellow
	green	54
7	0	green
39	4	green
	green	55
8	1	green
40	5	green
	green	56
9	1	green
41	5	green
	green	57
10	1	green
42	5	green
	green	58
11	1	green
43	5	green
	green	59
12	1	yellow
44	5	green
	green	60
13	1	green
45	5	green
	green	61
14	1	yellow
46	5	green
	green	62
15	1	green
47	5	green
	green	63

```
profile name: default
  profile type: dscp-to-dscp (Egress)
  Status: Inactive
mapping:
```

INPUT			OUTPUT	INPUT			OUTPUT	INPUT		
-----+-----				-----+-----				-----+-----		
+-----				+-----				+-----		
DSCP	Color	Out DSCP		DSCP	Color	Out DSCP		DSCP	Color	
-----+-----+-----				-----+-----+-----				-----+-----		
+-----				+-----				+-----		
0	green	0		0	yellow	0		0	red	
1	green	1		1	yellow	1		1	red	
2	green	2		2	yellow	2		2	red	
3	green	3		3	yellow	3		3	red	
4	green	4		4	yellow	4		4	red	
5	green	5		5	yellow	5		5	red	
6	green	6		6	yellow	6		6	red	
7	green	7		7	yellow	7		7	red	
8	green	8		8	yellow	8		8	red	
9	green	9		9	yellow	9		9	red	
10	green	10		10	yellow	12		10	red	
11	green	11		11	yellow	11		11	red	
12	green	12		12	yellow	12		12	red	
13	green	13		13	yellow	13		13	red	
14	green	14		14	yellow	14		14	red	
15	green	15		15	yellow	15		15	red	
16	green	16		16	yellow	16		16	red	
17	green	17		17	yellow	17		17	red	
18	green	18		18	yellow	20		18	red	
19	green	19		19	yellow	19		19	red	
20	green	20		20	yellow	20		20	red	
21	green	21		21	yellow	21		21	red	
22	green	22		22	yellow	22		22	red	
23	green	23		23	yellow	23		23	red	
24	green	24		24	yellow	24		24	red	
25	green	25		25	yellow	25		25	red	
26	green	26		26	yellow	28		26	red	

27	green	27		27	yellow	27		27	red
27									
28	green	28		28	yellow	28		28	red
30									
29	green	29		29	yellow	29		29	red
29									
30	green	30		30	yellow	30		30	red
30									
31	green	31		31	yellow	31		31	red
31									
32	green	32		32	yellow	32		32	red
32									
33	green	33		33	yellow	33		33	red
33									
34	green	34		34	yellow	36		34	red
38									
35	green	35		35	yellow	35		35	red
35									
36	green	36		36	yellow	36		36	red
38									
37	green	37		37	yellow	37		37	red
37									
38	green	38		38	yellow	38		38	red
38									
39	green	39		39	yellow	39		39	red
39									
40	green	40		40	yellow	40		40	red
40									
41	green	41		41	yellow	41		41	red
41									
42	green	42		42	yellow	42		42	red
42									
43	green	43		43	yellow	43		43	red
43									
44	green	44		44	yellow	44		44	red
44									
45	green	45		45	yellow	45		45	red
45									
46	green	46		46	yellow	46		46	red
46									
47	green	47		47	yellow	47		47	red
47									
48	green	48		48	yellow	48		48	red
48									
49	green	49		49	yellow	49		49	red
49									
50	green	50		50	yellow	50		50	red
50									
51	green	51		51	yellow	51		51	red
51									
52	green	52		52	yellow	52		52	red
52									
53	green	53		53	yellow	53		53	red
53									
54	green	54		54	yellow	54		54	red
54									
55	green	55		55	yellow	55		55	red
55									
56	green	56		56	yellow	56		56	red
56									
57	green	57		57	yellow	57		57	red
57									

```
profile name: default
  profile type: exp-to-queue (Ingress)
  mapping:
```

+-----+-----+		
INPUT	OUTPUT	
+-----+-----+		
EXP	TC	Color
+-----+-----+		
0	0	green
1	1	green
2	2	green
3	3	green
4	4	green
5	5	green
6	6	green
7	7	green

```
profile name: TEST1
  profile type: exp-encap (Egress)
  mapping:
```

L3 DSCP to EXP							
INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT
DSCP	EXP	DSCP	EXP	DSCP	EXP	DSCP	EXP
0	0	16	2	32	4	48	6
1	0	17	2	33	4	49	6
2	0	18	2	34	4	50	6
3	0	19	2	35	4	51	6
4	0	20	2	36	4	52	6
5	5	21	2	37	4	53	6
6	0	22	2	38	4	54	6
7	0	23	2	39	4	55	6
8	1	24	3	40	5	56	7
9	1	25	3	41	5	57	7
10	1	26	3	42	5	58	7
11	1	27	3	43	5	59	7
12	1	28	3	44	5	60	7
13	1	29	3	45	5	61	7
14	1	30	3	46	5	62	7
15	1	31	3	47	5	63	7

L2 Traffic-Class + Color to EXP

INPUT			OUTPUT			INPUT			OUTPUT			INPUT			OUTPUT		
TC	Color	EXP	TC	Color	EXP	TC	Color	EXP	TC	Color	EXP	TC	Color	EXP	TC	Color	EXP
0	green	0	0	yellow	0	0	red	0	0	red	0	0	red	0	0	red	0
1	green	1	1	yellow	1	1	red	1	1	red	1	1	red	1	1	red	1
2	green	2	2	yellow	2	2	red	2	2	red	2	2	red	2	2	red	2
3	green	3	3	yellow	3	3	red	3	3	red	3	3	red	3	3	red	3
4	green	4	4	yellow	4	4	red	4	4	red	4	4	red	4	4	red	4
5	green	5	5	yellow	5	5	red	5	5	red	5	5	red	5	5	red	5
6	green	6	6	yellow	6	6	red	6	6	red	6	6	red	6	6	red	6
7	green	7	7	yellow	7	7	red	7	7	red	7	7	red	7	7	red	7

```

PE1#show qos TEST1
profile name: TEST1
profile type: exp-encap
profile attached to 1 instances
configured mapping:
 13 dscp 5 exp 5
Detailed mapping:
L3 DSCP to EXP
    
```

INPUT		OUTPUT		INPUT		OUTPUT		INPUT		OUTPUT		INPUT		OUTPUT	
DSCP	EXP	DSCP	EXP	DSCP	EXP	DSCP	EXP	DSCP	EXP	DSCP	EXP	DSCP	EXP	DSCP	EXP
0	0	16	2	32	4	48	6	0	0	16	2	32	4	48	6
1	0	17	2	33	4	49	6	1	0	17	2	33	4	49	6
2	0	18	2	34	4	50	6	2	0	18	2	34	4	50	6
3	0	19	2	35	4	51	6	3	0	19	2	35	4	51	6
4	0	20	2	36	4	52	6	4	0	20	2	36	4	52	6
5	5	21	2	37	4	53	6	5	5	21	2	37	4	53	6
6	0	22	2	38	4	54	6	6	0	22	2	38	4	54	6
7	0	23	2	39	4	55	6	7	0	23	2	39	4	55	6
8	1	24	3	40	5	56	7	8	1	24	3	40	5	56	7
9	1	25	3	41	5	57	7	9	1	25	3	41	5	57	7
10	1	26	3	42	5	58	7	10	1	26	3	42	5	58	7
11	1	27	3	43	5	59	7	11	1	27	3	43	5	59	7
12	1	28	3	44	5	60	7	12	1	28	3	44	5	60	7
13	1	29	3	45	5	61	7	13	1	29	3	45	5	61	7
14	1	30	3	46	5	62	7	14	1	30	3	46	5	62	7
15	1	31	3	47	5	63	7	15	1	31	3	47	5	63	7

L2 Traffic-Class + Color to EXP

INPUT			OUTPUT			INPUT			OUTPUT			INPUT			OUTPUT		
TC	Color	EXP	TC	Color	EXP	TC	Color	EXP	TC	Color	EXP	TC	Color	EXP	TC	Color	EXP

0	green	0		0	yellow	0		0	red	0
1	green	1		1	yellow	1		1	red	1
2	green	2		2	yellow	2		2	red	2
3	green	3		3	yellow	3		3	red	3
4	green	4		4	yellow	4		4	red	4
5	green	5		5	yellow	5		5	red	5
6	green	6		6	yellow	6		6	red	6
7	green	7		7	yellow	7		7	red	7

PE2

```
PE2#show qos int xel
profile name: default
profile type: dscp-to-queue (Ingress)
mapping:
```

INPUT				OUTPUT				INPUT				OUTPUT			
INPUT				OUTPUT				INPUT				OUTPUT			
OUTPUT															
DSCP				TC				DSCP				TC			
Color				Out DSCP				Color				Out DSCP			
TC				Color				Out DSCP				Color			
0	0	green	0	0	0	16	2	green	16						
32	4	green	32	0	48	6									
	green	48													
1	0	green	1	1	17	2		green	17						
33	4	green	33	1	49	6									
	green	49													
2	0	green	2	2	18	2		green	18						
34	4	green	34	2	50	6									
	green	50													
3	0	green	3	3	19	2		green	19						
35	4	green	35	3	51	6									
	green	51													
4	0	green	4	4	20	2		yellow	20						
36	4	yellow	36	4	52	6									
	green	52													
5	0	green	5	5	21	2		green	21						
37	4	green	37	5	53	6									
	green	53													
6	0	green	6	6	22	2		yellow	22						
38	4	yellow	38	6	54	6									
	green	54													
7	0	green	7	7	23	2		green	23						
39	4	green	39	7	55	6									
	green	55													
8	1	green	8	8	24	3		green	24						
40	5	green	40	8	56	7									
	green	56													
9	1	green	9	9	25	3		green	25						
41	5	green	41	9	57	7									

```
profile type: dscp-to-dscp (Egress)
Status: Inactive
```

+-----+					+-----+					+-----+			
INPUT OUTPUT					INPUT OUTPUT					INPUT			
OUTPUT													
+-----+					+-----+					+-----+			
DSCP Color Out DSCP					DSCP Color Out DSCP					DSCP Color			
Out DSCP													
+-----+					+-----+					+-----+			
+-----+					+-----+					+-----+			
0	0	green	0		0	yellow	0		0	red			
1	1	green	1		1	yellow	1		1	red			
2	2	green	2		2	yellow	2		2	red			
3	3	green	3		3	yellow	3		3	red			
4	4	green	4		4	yellow	4		4	red			
5	5	green	5		5	yellow	5		5	red			
6	6	green	6		6	yellow	6		6	red			
7	7	green	7		7	yellow	7		7	red			
8	8	green	8		8	yellow	8		8	red			
9	9	green	9		9	yellow	9		9	red			
14	10	green	10		10	yellow	12		10	red			
11	11	green	11		11	yellow	11		11	red			
14	12	green	12		12	yellow	12		12	red			

13	green	13		13	yellow	13		13	red
13									
14	green	14		14	yellow	14		14	red
14									
15	green	15		15	yellow	15		15	red
15									
16	green	16		16	yellow	16		16	red
16									
17	green	17		17	yellow	17		17	red
17									
18	green	18		18	yellow	20		18	red
22									
19	green	19		19	yellow	19		19	red
19									
20	green	20		20	yellow	20		20	red
22									
21	green	21		21	yellow	21		21	red
21									
22	green	22		22	yellow	22		22	red
22									
23	green	23		23	yellow	23		23	red
23									
24	green	24		24	yellow	24		24	red
24									
25	green	25		25	yellow	25		25	red
25									
26	green	26		26	yellow	28		26	red
30									
27	green	27		27	yellow	27		27	red
27									
28	green	28		28	yellow	28		28	red
30									
29	green	29		29	yellow	29		29	red
29									
30	green	30		30	yellow	30		30	red
30									
31	green	31		31	yellow	31		31	red
31									
32	green	32		32	yellow	32		32	red
32									
33	green	33		33	yellow	33		33	red
33									
34	green	34		34	yellow	36		34	red
38									
35	green	35		35	yellow	35		35	red
35									
36	green	36		36	yellow	36		36	red
38									
37	green	37		37	yellow	37		37	red
37									
38	green	38		38	yellow	38		38	red
38									
39	green	39		39	yellow	39		39	red
39									
40	green	40		40	yellow	40		40	red
40									
41	green	41		41	yellow	41		41	red
41									
42	green	42		42	yellow	42		42	red
42									
43	green	43		43	yellow	43		43	red
43									

44	green	44		44	yellow	44		44	red
44									
45	green	45		45	yellow	45		45	red
45									
46	green	46		46	yellow	46		46	red
46									
47	green	47		47	yellow	47		47	red
47									
48	green	48		48	yellow	48		48	red
48									
49	green	49		49	yellow	49		49	red
49									
50	green	50		50	yellow	50		50	red
50									
51	green	51		51	yellow	51		51	red
51									
52	green	52		52	yellow	52		52	red
52									
53	green	53		53	yellow	53		53	red
53									
54	green	54		54	yellow	54		54	red
54									
55	green	55		55	yellow	55		55	red
55									
56	green	56		56	yellow	56		56	red
56									
57	green	57		57	yellow	57		57	red
57									
58	green	58		58	yellow	58		58	red
58									
59	green	59		59	yellow	59		59	red
59									
60	green	60		60	yellow	60		60	red
60									
61	green	61		61	yellow	61		61	red
61									
62	green	62		62	yellow	62		62	red
62									
63	green	63		63	yellow	63		63	red
63									

profile name: default
 profile type: exp-to-queue (Ingress)
 mapping:

INPUT OUTPUT		
-----+-----		
EXP	TC	Color
-----+-----		
0	0	green
1	1	green
2	2	green
3	3	green
4	4	green
5	7	green
6	6	green
7	7	green

profile name: default
 profile type: exp-encap (Egress)

mapping:

L3 DSCP to EXP

INPUT		OUTPUT		INPUT		OUTPUT		INPUT		OUTPUT	
DSCP	EXP	DSCP	EXP	DSCP	EXP	DSCP	EXP	DSCP	EXP	DSCP	EXP
0	0	16	2	32	4	48	6				
1	0	17	2	33	4	49	6				
2	0	18	2	34	4	50	6				
3	0	19	2	35	4	51	6				
4	0	20	2	36	4	52	6				
5	0	21	2	37	4	53	6				
6	0	22	2	38	4	54	6				
7	0	23	2	39	4	55	6				
8	1	24	3	40	5	56	7				
9	1	25	3	41	5	57	7				
10	1	26	3	42	5	58	7				
11	1	27	3	43	5	59	7				
12	1	28	3	44	5	60	7				
13	1	29	3	45	5	61	7				
14	1	30	3	46	5	62	7				
15	1	31	3	47	5	63	7				

L2 Traffic-Class + Color to EXP

INPUT			OUTPUT			INPUT			OUTPUT		
TC	Color	EXP	TC	Color	EXP	TC	Color	EXP	TC	Color	EXP
0	green	0	0	yellow	0	0	red	0			
1	green	1	1	yellow	1	1	red	1			
2	green	2	2	yellow	2	2	red	2			
3	green	3	3	yellow	3	3	red	3			
4	green	4	4	yellow	4	4	red	4			
5	green	5	5	yellow	5	5	red	5			
6	green	6	6	yellow	6	6	red	6			
7	green	7	7	yellow	7	7	red	7			

PE2#show qos default

profile name: default

profile type: cos-to-queue

configured mapping:

Detailed mapping:

INPUT				OUTPUT			
COS	DEI	TC	Color	COS	DEI	TC	Color
0	0	0	green	0	1	0	yellow
1	0	1	green	1	1	1	yellow
2	0	2	green	2	1	2	yellow
3	0	3	green	3	1	3	yellow

4	0	4	green		4	1	4	yellow
5	0	5	green		5	1	5	yellow
6	0	6	green		6	1	6	yellow
7	0	7	green		7	1	7	yellow

profile name: default
 profile type: queue-color-to-cos
 configured mapping:
 Detailed mapping:

INPUT			OUTPUT			INPUT			OUTPUT			INPUT			OUTPUT		
TC	Color	COS	TC	Color	COS	TC	Color	COS	TC	Color	COS	TC	Color	COS	TC	Color	COS
0	green	0	0	yellow	0	0	red	0	0	red	0	0	red	0	0	red	0
1	green	1	1	yellow	1	1	red	1	1	red	1	1	red	1	1	red	1
2	green	2	2	yellow	2	2	red	2	2	red	2	2	red	2	2	red	2
3	green	3	3	yellow	3	3	red	3	3	red	3	3	red	3	3	red	3
4	green	4	4	yellow	4	4	red	4	4	red	4	4	red	4	4	red	4
5	green	5	5	yellow	5	5	red	5	5	red	5	5	red	5	5	red	5
6	green	6	6	yellow	6	6	red	6	6	red	6	6	red	6	6	red	6
7	green	7	7	yellow	7	7	red	7	7	red	7	7	red	7	7	red	7

profile name: default
 profile type: dscp-to-queue
 configured mapping:
 Detailed mapping:

INPUT				OUTPUT				INPUT				OUTPUT			
DSCP	TC	Color	Out DSCP	DSCP	TC	Color	Out DSCP	DSCP	TC	Color	Out DSCP	DSCP	TC	Color	Out DSCP
0	0	green	0	16	2	green	16	32	4	green	32	48	6	green	48
1	0	green	1	17	2	green	17	33	4	green	33	49	6	green	49
2	0	green	2	18	2	green	18	34	4	green	34	50	6	green	50
3	0	green	3	19	2	green	19	35	4	green	35	51	6	green	51

36	4	0	green	4		20	2	yellow	20	
	4		yellow	36		52	6			
		green	52							
37	5	0	green	5		21	2	green	21	
	4		green	37		53	6			
		green	53							
38	6	0	green	6		22	2	yellow	22	
	4		yellow	38		54	6			
		green	54							
39	7	0	green	7		23	2	green	23	
	4		green	39		55	6			
		green	55							
40	8	1	green	8		24	3	green	24	
	5		green	40		56	7			
		green	56							
41	9	1	green	9		25	3	green	25	
	5		green	41		57	7			
		green	57							
42	10	1	green	10		26	3	green	26	
	5		green	42		58	7			
		green	58							
43	11	1	green	11		27	3	green	27	
	5		green	43		59	7			
		green	59							
44	12	1	yellow	12		28	3	yellow	28	
	5		green	44		60	7			
		green	60							
45	13	1	green	13		29	3	green	29	
	5		green	45		61	7			
		green	61							
46	14	1	yellow	14		30	3	yellow	30	
	5		green	46		62	7			
		green	62							
47	15	1	green	15		31	3	green	31	
	5		green	47		63	7			
		green	63							

profile name: default

profile type: queue-color-to-dscp

configured mapping:

Detailed mapping:

INPUT			OUTPUT			INPUT			OUTPUT		
TC	Color	DSCP	TC	Color	DSCP	TC	Color	DSCP	TC	Color	DSCP
0	green	0	0	yellow	0	0	red	0	0	red	0
1	green	10	1	yellow	12	1	red	14	1	red	14
2	green	18	2	yellow	20	2	red	22	2	red	22
3	green	26	3	yellow	28	3	red	30	3	red	30
4	green	34	4	yellow	36	4	red	38	4	red	38
5	green	40	5	yellow	40	5	red	40	5	red	40
6	green	48	6	yellow	48	6	red	48	6	red	48
7	green	56	7	yellow	56	7	red	56	7	red	56

profile name: default
 profile type: dscp-to-dscp
 configured mapping:
 Detailed mapping:

INPUT			OUTPUT			INPUT			OUTPUT			INPUT			OUTPUT		
DSCP	Color	Out DSCP	DSCP	Color	Out DSCP	DSCP	Color	Out DSCP	DSCP	Color	Out DSCP	DSCP	Color	Out DSCP	DSCP	Color	Out DSCP
0	green	0	0	yellow	0	0	red										
1	green	1	1	yellow	1	1	red										
2	green	2	2	yellow	2	2	red										
3	green	3	3	yellow	3	3	red										
4	green	4	4	yellow	4	4	red										
5	green	5	5	yellow	5	5	red										
6	green	6	6	yellow	6	6	red										
7	green	7	7	yellow	7	7	red										
8	green	8	8	yellow	8	8	red										
9	green	9	9	yellow	9	9	red										
10	green	10	10	yellow	12	10	red										
11	green	11	11	yellow	11	11	red										
12	green	12	12	yellow	12	12	red										
13	green	13	13	yellow	13	13	red										
14	green	14	14	yellow	14	14	red										
15	green	15	15	yellow	15	15	red										
16	green	16	16	yellow	16	16	red										
17	green	17	17	yellow	17	17	red										
18	green	18	18	yellow	20	18	red										
19	green	19	19	yellow	19	19	red										
20	green	20	20	yellow	20	20	red										
21	green	21	21	yellow	21	21	red										
22	green	22	22	yellow	22	22	red										
23	green	23	23	yellow	23	23	red										

24	green	24		24	yellow	24		24	red
24									
25	green	25		25	yellow	25		25	red
25									
26	green	26		26	yellow	28		26	red
30									
27	green	27		27	yellow	27		27	red
27									
28	green	28		28	yellow	28		28	red
30									
29	green	29		29	yellow	29		29	red
29									
30	green	30		30	yellow	30		30	red
30									
31	green	31		31	yellow	31		31	red
31									
32	green	32		32	yellow	32		32	red
32									
33	green	33		33	yellow	33		33	red
33									
34	green	34		34	yellow	36		34	red
38									
35	green	35		35	yellow	35		35	red
35									
36	green	36		36	yellow	36		36	red
38									
37	green	37		37	yellow	37		37	red
37									
38	green	38		38	yellow	38		38	red
38									
39	green	39		39	yellow	39		39	red
39									
40	green	40		40	yellow	40		40	red
40									
41	green	41		41	yellow	41		41	red
41									
42	green	42		42	yellow	42		42	red
42									
43	green	43		43	yellow	43		43	red
43									
44	green	44		44	yellow	44		44	red
44									
45	green	45		45	yellow	45		45	red
45									
46	green	46		46	yellow	46		46	red
46									
47	green	47		47	yellow	47		47	red
47									
48	green	48		48	yellow	48		48	red
48									
49	green	49		49	yellow	49		49	red
49									
50	green	50		50	yellow	50		50	red
50									
51	green	51		51	yellow	51		51	red
51									
52	green	52		52	yellow	52		52	red
52									
53	green	53		53	yellow	53		53	red
53									
54	green	54		54	yellow	54		54	red
54									

55	green	55		55	yellow	55		55	red
56	green	56		56	yellow	56		56	red
57	green	57		57	yellow	57		57	red
58	green	58		58	yellow	58		58	red
59	green	59		59	yellow	59		59	red
60	green	60		60	yellow	60		60	red
61	green	61		61	yellow	61		61	red
62	green	62		62	yellow	62		62	red
63	green	63		63	yellow	63		63	red

profile name: default
 profile type: dscp-encap
 configured mapping:
 Detailed mapping:

L3 DSCP to DSCP-ENCAP

INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT
DSCP	DSCP	DSCP	DSCP	DSCP	DSCP	DSCP	DSCP
0	0	16	16	32	32	48	48
1	1	17	17	33	33	49	49
2	2	18	18	34	34	50	50
3	3	19	19	35	35	51	51
4	4	20	20	36	36	52	52
5	5	21	21	37	37	53	53
6	6	22	22	38	38	54	54
7	7	23	23	39	39	55	55
8	8	24	24	40	40	56	56
9	9	25	25	41	41	57	57
10	10	26	26	42	42	58	58
11	11	27	27	43	43	59	59
12	12	28	28	44	44	60	60
13	13	29	29	45	45	61	61
14	14	30	30	46	46	62	62
15	15	31	31	47	47	63	63

L2 Traffic-Class + Color to DSCP-ENCAP

INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT
TC	Color	TC	Color	TC	Color
0	green	0	yellow	0	red
1	green	1	yellow	1	red
2	green	2	yellow	2	red
3	green	3	yellow	3	red
4	green	4	yellow	4	red
5	green	5	yellow	5	red

6	green	48		6	yellow	48		6	red	48
7	green	56		7	yellow	56		7	red	56

```
profile name: default
profile type: exp-to-queue
configured mapping:
qos profile exp-to-queue default
exp 5 queue 7
!
```

Detailed mapping:

-----+-----		
INPUT	OUTPUT	
-----+-----		
EXP	TC	Color
-----+-----		
0	0	green
1	1	green
2	2	green
3	3	green
4	4	green
5	7	green
6	6	green
7	7	green

```
profile name: default
profile type: exp-encap
configured mapping:
Detailed mapping:
```

L3 DSCP to EXP

-----+-----		-----+-----		-----+-----		-----+-----	
INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT
-----+-----		-----+-----		-----+-----		-----+-----	
DSCP	EXP	DSCP	EXP	DSCP	EXP	DSCP	EXP
-----+-----		-----+-----		-----+-----		-----+-----	
0	0	16	2	32	4	48	6
1	0	17	2	33	4	49	6
2	0	18	2	34	4	50	6
3	0	19	2	35	4	51	6
4	0	20	2	36	4	52	6
5	0	21	2	37	4	53	6
6	0	22	2	38	4	54	6
7	0	23	2	39	4	55	6
8	1	24	3	40	5	56	7
9	1	25	3	41	5	57	7
10	1	26	3	42	5	58	7
11	1	27	3	43	5	59	7
12	1	28	3	44	5	60	7
13	1	29	3	45	5	61	7
14	1	30	3	46	5	62	7
15	1	31	3	47	5	63	7

L2 Traffic-Class + Color to EXP

-----+-----		-----+-----		-----+-----	
INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT
-----+-----		-----+-----		-----+-----	
OUTPUT					

-----+-----				-----+-----				-----+-----		
-----				-----				-----		
TC	Color	EXP		TC	Color	EXP		TC	Color	EXP
-----+-----+-----				-----+-----+-----				-----+-----+-----		
0	green	0		0	yellow	0		0	red	0
1	green	1		1	yellow	1		1	red	1
2	green	2		2	yellow	2		2	red	2
3	green	3		3	yellow	3		3	red	3
4	green	4		4	yellow	4		4	red	4
5	green	5		5	yellow	5		5	red	5
6	green	6		6	yellow	6		6	red	6
7	green	7		7	yellow	7		7	red	7

CHAPTER 7 Policing Configuration

This chapter contains a complete sample of configuration of Policing for Pipe and Uniform models. This example shows configurations using LDP.

Configuration

Configuring Remarking for MPLS EXP bits require following configurations:

- Enabling label-switching on the interface on NSM.
- Configuring LSP (Using LDP, Static or RSVP-TE, in this example we are using LDP for setting UP LSP).
- Running an IGP (Internal Gateway Protocol), for example, OSPF, to distribute reachability information within the MPLS cloud.
- Enable QoS, Configuring Policing on interface Level.

Topology

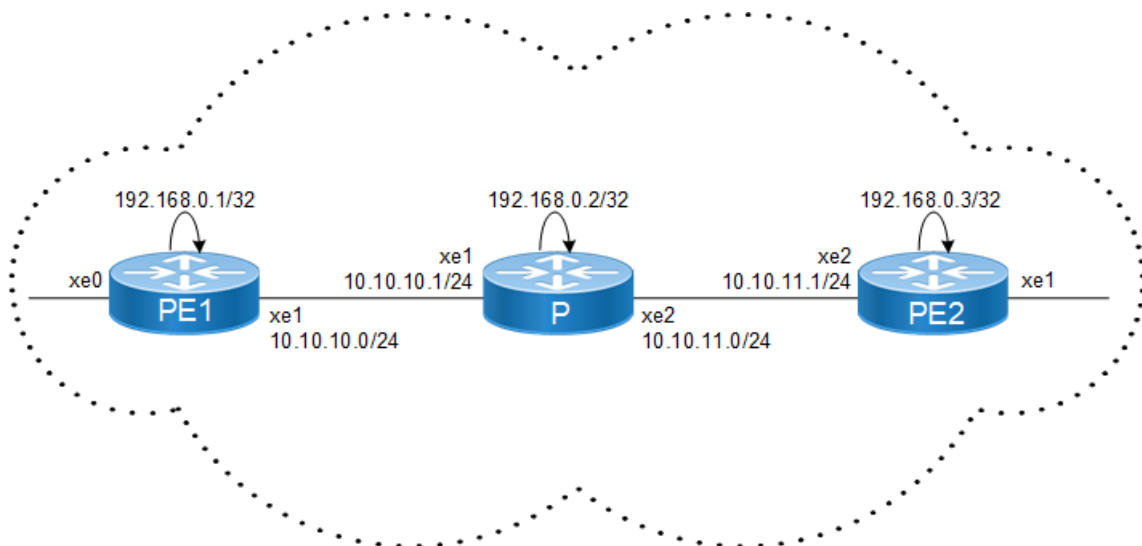


Figure 7-3: Basic Policing Topology

The following steps describes how to configure Policing.

PE1:NSM

#configure terminal	Enter configure mode
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.10.10.1/24	Configure IP address for the interface
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.

(config-if)#ip address 192.168.0.1/32 secondary	Set the IP address of the loopback interface to 192.168.0.1/32
(config-if)#commit	Commit the transaction.

PE1:OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.10.10.0/24 area 0 (config-router)#network 192.168.0.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

PE1:LDP

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 192.168.0.1	Set the router ID to IP address 192.168.0.1.
(config-router)#transport-address ipv4 192.168.0.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe1.
(config-if)#commit	Commit the transaction.

PE1

#configure terminal	Enter configure mode.
(config)#qos enable	Enable QoS.
(config)#hardware-profile filter qos enable	Enable QoS hardware.
(config)#commit	Commit candidate configuration to the running configuration.
(config)#class-map cmap1	Enter Class-map mode.
(config-cmap-qos)#match dscp 2	Configure match criteria as DSCP with Value 2.
(config-cmap-qos)#exit	Exit Class-map mode.
(config)#commit	Commit candidate configuration to the running configuration.
(config)#policy-map pmap1	Enter policy-map mode.
(config-pmap-qos)#class cmap1	Assign Class cmap1 to Policy-map pmap1.
(config-pmap-c-qos)#police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes	Police DSCP 2 packets @ Committed information rate 1 mbps.

(config-pmap-c-qos) #exit	Exit out of policy-class-map mode.
(config-pmap-qos) #exit	Exit out of Policy-map mode.
(config) #commit	Commit candidate configuration to the running configuration.
(config) #interface xe1	Enter xe1 interface.
(config-if) #service-policy type qos input pmap1	Assign service-policy to interface on in-direction.
(config-if) #exit	Exit interface mode.
(config) #commit	Commit candidate configuration to the running configuration.

P:NSM

#configure terminal	Enter configure mode.
(config) #interface xe1	Specify the interface (xe1) to be configured.
(config-if) #ip address 10.10.10.2/24	Configure IP address for the interface.
(config-if) #label-switching	Enable label switching on interface xe1.
(config-if) #exit	Exit interface mode.
(config) #interface xe2	Specify the interface (xe2) to be configured.
(config-if) #ip address 10.10.11.1/24	Configure IP address for the interface.
(config-if) #label-switching	Enable label switching on interface xe1.
(config-if) #exit	Exit interface mode.
(config) #interface lo	Specify the loopback (lo) interface to be configured.
(config-if) #ip address 192.168.0.2/32 secondary	Set the IP address of the loopback interface to 192.168.0.2/32.
(config-if) #commit	Commit the transaction.

P:OSPF

#configure terminal	Enter configure mode.
(config) #router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router) #network 10.10.10.0/24 area 0 (config-router) #network 10.10.11.0/24 area 0 (config-router) #network 192.168.0.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router) #commit	Commit the transaction.

P:LDP

#configure terminal	Enter configure mode.
(config) #router ldp	Enter Router mode for LDP.
(config-router) #router-id 192.168.0.2	Set the router ID to IP address 192.168.0.2.

(config-router)#transport-address ipv4 192.168.0.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#commit	Commit the transaction.

PE2:NSM

#configure terminal	Enter configure mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#ip address 10.10.11.2/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 192.168.0.3/32 secondary	Set the IP address of the loopback interface to 192.168.0.3/32.
(config-if)#commit	Commit the transaction.

PE2:OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.10.11.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 192.168.0.3/32 area 0	
(config-router)#commit	Commit the transaction.

PE2:LDP

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 192.168.0.3	Set the router ID to IP address 192.168.0.3.
(config-router)#explicit-null	To disable PHP.
(config-router)#transport-address ipv4 192.168.0.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address.

(config-router)#exit	Exit router mode.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#qos enable	Enable QoS.
(config)#hardware-profile filter qos enable	Enable QoS hardware.
(config)#commit	Commit candidate configuration to the running configuration.
(config)#class-map cmap1	Enter Class-map mode.
(config-cmap-qos)#match dscp 2	Configure match criteria as DSCP with Value 2.
(config-cmap-qos)#exit	Exit Class-map mode.
(config)#commit	Commit candidate configuration to the running configuration.
(config)#policy-map pmap1	Enter policy-map mode.
(config-pmap-qos)#class cmap1	Assign Class cmap1 to Policy-map pmap1.
(config-pmap-c-qos)#police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes	Police DSCP 2 packets @ Committed information rate 1 mbps.
(config-pmap-c-qos)#exit	Exit out of policy-class-map mode.
(config-pmap-qos)#exit	Exit out of Policy-map mode.
(config)#commit	Commit candidate configuration to the running configuration.
(config)#interface xe1	Enter xe1 interface.
(config-if)#service-policy type qos input pmap1	Assign service-policy to interface on in-direction.
(config-if)#exit	Exit interface mode.
(config)#commit	Commit candidate configuration to the running configuration.

Validation

PE1

```
PE1#show class-map
```

```
Type qos class-maps
```

```
=====
```

```
class-map type qos match-any class-default
```

```
class-map type qos match-allcmap1
match dscp 2
```

```
Type queuing class-maps
```

```
=====
```

```
class-map type queuing class-default-q
```

```
class-map type queuing q0
class-map type queuing q1
class-map type queuing q2
class-map type queuing q3
class-map type queuing q4
class-map type queuing q5
class-map type queuing q6
class-map type queuing q7

Type Vlan-Queuing class-maps
=====

#show running-config qos
qos enable
!
class-map type qos match-all cmap1

match dscp 2
!
policy-map type qos pmap1
class type qos cmap1
police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes
exit
!
!
!
interface xe1
service-policy type qos input pmap1
#

#show policy-map

Type qos policy-maps
=====

policy-map type qospmap1
class Type qos cmap1
police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes

Type queuing policy-maps
=====

policy-map type queuing default default-out-policy
class type queuing default q0
priority level 0
exit
class type queuing default q1
```

```
priority level 1
exit
class type queuing default q2
priority level 2
exit
class type queuing default q3
priority level 3
exit
class type queuing default q4
priority level 4
exit
class type queuing default q5
priority level 5
exit
class type queuing default q6
priority level 6
exit
class type queuing default q7
priority level 7

policy-map type queuing default subif-default-out-policy
class type queuing default q0
priority level 0
class type queuing default q1
priority level 1
class type queuing default q2
priority level 2
class type queuing default q3
priority level 3
```

```
#show policy-map interface xe1
=====
```

```
Interface xe1
```

```
Type QoS statistics status : disabled
=====
```

```
Class-map (qos): cmap1 (match all)
  match dscp 2
  police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes
```

```
Type Queuing policy-map : default-out-policy
=====
```

```
Class-map (queuing): q0
  shape 10000000 kbps (inherited)
  priority level 0
  queue-limit 12517376 bytes/10 ms (default)
```

```
Class-map (queuing): q1
  shape 10000000 kbps (inherited)
  priority level 1
  queue-limit 12517376 bytes/10 ms (default)
```

```

Class-map (queuing): q2
  shape 10000000 kbps (inherited)
  priority level 2
  queue-limit 12517376 bytes/10 ms (default)

Class-map (queuing): q3
  shape 10000000 kbps (inherited)
  priority level 3
  queue-limit 12517376 bytes/10 ms (default)

Class-map (queuing): q4
  shape 10000000 kbps (inherited)
  priority level 4
  queue-limit 12517376 bytes/10 ms (default)

Class-map (queuing): q5
  shape 10000000 kbps (inherited)
  priority level 5
  queue-limit 12517376 bytes/10 ms (default)

Class-map (queuing): q6
  shape 10000000 kbps (inherited)
  priority level 6
  queue-limit 12517376 bytes/10 ms (default)
  Output
    Total      : 7 packets, 816 bytes
    Green      : 7 packets, 816 bytes
    Yellow     : 0 packets, 0 bytes

Class-map (queuing): q7
  shape 10000000 kbps (inherited)
  priority level 7
  queue-limit 12517376 bytes/10 ms (default)

```

PE2

```

OcNOS#show class-map

Type qos class-maps
=====
  class-map type qos match-any class-default

  class-map type qos match-all cmap1
    match dscp 2

Type queuing class-maps
=====
  class-map type queuing class-default-q

  class-map type queuing q0

  class-map type queuing q1

  class-map type queuing q2

```

```
class-map type queuing q3

class-map type queuing q4

class-map type queuing q5

class-map type queuing q6

class-map type queuing q7
```

```
OcNOS#show running-config qos
qos enable
!
class-map type qos match-all cmap1
  match dscp 2
!
policy-map type qos pmap1
  class type qos cmap1
    police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes
  exit
!
!
!
interface xe1
  service-policy type qos input pmap1
!
```

```
OcNOS#show policy-map
```

```
Type qos policy-maps
=====
```

```
policy-map type qos pmap1
  class type qos cmap1
    police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes
```

```
Type queuing policy-maps
=====
```

```
policy-map type queuing default default-out-policy
  class type queuing default q0
    priority level 0
  class type queuing default q1
    priority level 1
  class type queuing default q2
    priority level 2
  class type queuing default q3
    priority level 3
  class type queuing default q4
    priority level 4
  class type queuing default q5
```

```
    priority level 5
    class type queuing default q6
    priority level 6
    class type queuing default q7
    priority level 7

policy-map type queuing default subif-default-out-policy
  class type queuing default q0
  priority level 0
  class type queuing default q1
  priority level 1
  class type queuing default q2
  priority level 2
  class type queuing default q3
  priority level 3

OcNOS#show policy-map int xe15

Interface xe15

Type QoS statistics status : disabled

Type QoS Ingress policy-map : pmap1

Class-map (qos): cmap1 (match all)
  match dscp 2
  police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes

Type Queuing policy-map : default-out-policy

Class-map (queuing): q0
  shape 10000000 kbps (inherited)
  priority level 0
  queue-limit (default)
    Output
      Total      : 451 packets, 33887 bytes
      Green      : 451 packets, 33887 bytes
      Yellow     : 0 packets, 0 bytes

Class-map (queuing): q1
  shape 10000000 kbps (inherited)
  priority level 1
  queue-limit (default)

Class-map (queuing): q2
  shape 10000000 kbps (inherited)
  priority level 2
  queue-limit (default)

Class-map (queuing): q3
  shape 10000000 kbps (inherited)
  priority level 3
  queue-limit (default)

Class-map (queuing): q4
  shape 10000000 kbps (inherited)
```

```
priority level 4
queue-limit (default)
```

```
Class-map (queuing): q5
  shape 10000000 kbps (inherited)
  priority level 5
  queue-limit (default)
```

```
Class-map (queuing): q6
  shape 10000000 kbps (inherited)
  priority level 6
  queue-limit (default)
  Output
    Total      : 1119 packets, 100461 bytes
    Green      : 1119 packets, 100461 bytes
    Yellow     : 0 packets, 0 bytes
```

```
Class-map (queuing): q7
  shape 10000000 kbps (inherited)
  priority level 7
  queue-limit (default)
  Output
    Total      : 56 packets, 4088 bytes
    Green      : 56 packets, 4088 bytes
    Yellow     : 0 packets, 0 bytes
```


CHAPTER 8 MPLS Statistics Configuration

This chapter provides the configuration required for configuring MPLS LSPs and verifying the statistics of packets captured at the supported interfaces, in terms of both packet count and bytes, when traffic is sent.

Configure LDP-LSP

Topology

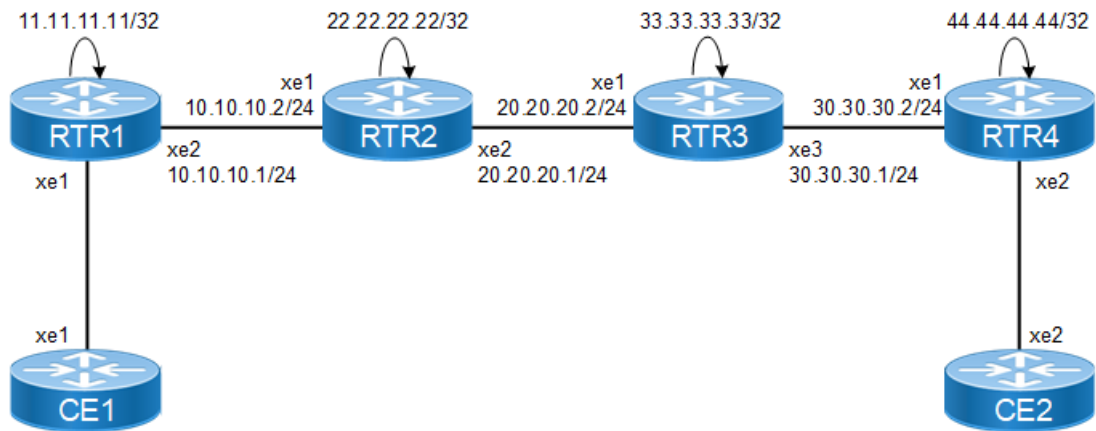


Figure 8-4: MPLS Statistics Topology

RTR1: Loopback Interface configuration

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the interface (lo) to be configured.
(config-if)#ip address 11.11.11.11/32 secondary	Configure IP address on loopback interface
(config-if)#commit	Commit the transaction.

RTR1: Global LDP configuration

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 11.11.11.11	Configure the router-id
(config-router)#transport-address ipv4 11.11.11.11	Configure the loopback address as transport-address
(config-router)#targeted-peer ipv4 44.44.44.44	Configure the loopback address of RTR4 as targeted peer.

(config-router-targeted-peer) #exit	Exit router-targeted-peer mode and enter config-router mode
(config-router-targeted-peer) #commit	Commit the transaction.

RTR1: Enabling LDP and label switching on interface

(config) #interface xe2	Enter interface mode for xe2.
(config-if) #enable-ldp ipv4	Enable LDP on the interface.
(config-if) #label-switching	Enable Label switching on the interface.
(config-if) #ip address 10.10.10.1/24	Configure IP address on the interface.
(config-if) #commit	Commit the transaction.

RTR1: Global OSPF configuration

(config) #router ospf 100	Enter the Router OSPF mode.
(config-router) #network 11.11.11.11/32 area 0	Advertise loopback address in OSPF.
(config-router) #network 10.10.10.0/24 area 0	Advertise network address (xe2) in OSPF.
(config-router) #commit	Commit the transaction.

RTR2: Loopback Interface configuration

#configure terminal	Enter configure mode.
(config) #interface lo	Specify the interface (lo) to be configured.
(config-if) #ip address 22.22.22.22/32 secondary	Configure IP address on loopback interface
(config-if) #commit	Commit the transaction.

RTR2: Global LDP configuration

(config) #router ldp	Enter Router mode for LDP.
(config-router) #router-id 22.22.22.22	Configure the router-id
(config-router) #transport-address ipv4 22.22.22.22	Configure the loopback address as transport-address
(config-router) #commit	Commit the transaction.

RTR2: Enabling LDP and label switching on interface

(config) #interface xe1	Enter interface mode for xe1.
(config-if) #enable-ldp ipv4	Enable LDP on the interface.

(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#ip address 10.10.10.2/24	Configure IP address on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode for xe2.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#ip address 20.20.20.1/24	Configure IP address on the interface.
(config-if)#commit	Commit the transaction.

RTR2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode
(config-router)#network 22.22.22.22/32 area 0.0.0.0	Advertise loopback address in OSPF
(config-router)#network 10.10.10.2/24 area 0.0.0.0	Advertise network address (xe1) in OSPF.
(config-router)#network 20.20.20.1/24 area 0.0.0.0	Advertise network address (xe2) in OSPF.
(config-router)#commit	Commit the transaction.

RTR3: Loopback Interface configuration

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the interface (lo) to be configured.
(config-if)#ip address 33.33.33.33/32 secondary	Configure IP address on loopback interface
(config-if)#commit	Commit the transaction.

RTR3: Global LDP configuration

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 33.33.33.33	Configure the router-id
(config-router)#transport-address ipv4 33.33.33.33	Configure the loopback address as transport-address
(config-router)#commit	Commit the transaction.

RTR3: Enabling LDP and label switching on interface

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.

(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#ip address 20.20.20.2/24	Configure IP address on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode for xe2.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#ip address 30.30.30.1/24	Configure IP address on the interface.
(config-if)#commit	Commit the transaction.

RTR3: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode
(config-router)#network 33.33.33.33/32 area 0.0.0.0	Advertise loopback address in OSPF
(config-router)#network 20.20.20.2/24 area 0.0.0.0	Advertise network address (xe1) in OSPF.
(config-router)#network 30.30.30.1/24 area 0.0.0.0	Advertise network address (xe2) in OSPF.
(config-router)#commit	Commit the transaction.

RTR4: Loopback Interface configuration

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the interface (lo) to be configured.
(config-if)#ip address 44.44.44.44/32 secondary	Configure IP address on loopback interface
(config-if)#commit	Commit the transaction.

RTR4: Global LDP configuration

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 44.44.44.44	Configure the router-id
(config-router)#transport-address ipv4 44.44.44.44	Configure the loopback address as transport-address
(config-router)#targeted-peer ipv4 11.11.11.11	Configure the loopback address of RTR1 as targeted peer.
(config-router-targeted-peer)#exit	Exit router-targeted-peer mode and enter config-router mode
(config-router)#commit	Commit the transaction.

RTR4: Enabling LDP and label switching on interface

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#ip address 30.30.30.2/24	Configure IP address on the interface.
(config-if)#commit	Commit the transaction.

RTR4: Global OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode
(config-router)#network 44.44.44.44/32 area 0.0.0.0	Advertise loopback address in OSPF
(config-router)#network 30.30.30.2/24 area 0.0.0.0	Advertise network address (xe1) in OSPF.
(config-router)#commit	Commit the transaction.

MPLS LDP VPLS Configuration**RTR1: VPLS**

(config)#mpls vpls vpls1 1	Enter the VPLS configuration mode
(config-vpls)# signaling ldp	Use LDP signaling for VPLS
(config-vpls-sig)#vpls-type ethernet	Configure the VPLS as Ethernet
(config-vpls-sig)#vpls-peer 44.44.44.44	Configure RTR4 as VPLS peer for RTR1.
(config-vpls-sig)#exit-signaling	Exit signaling mode
(config-vpls)# exit-vpls	Exit VPLS config mode and return to Configure mode
(config-vpls)#commit	Commit the transaction.

RTR1: Interface

(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe1	Enter the Interface mode for xe1
(config-if)#switchport	Enable switchport on the interface
(config-if)#mpls-vpls vpls1 service-template st1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if)#commit	Commit the transaction.

RTR4: VPLS

(config)#mpls vpls vpls1 1	Enter the VPLS configuration mode
(config-vpls)#signaling ldp	Use LDP signaling for VPLS
(config-vpls-sig)#vpls-type ethernet	Configure the VPLS as Ethernet
(config-vpls-sig)#vpls-peer 11.11.11.11	Configure RTR1 as VPLS peer for RTR4.
(config-vpls-sig)#exit-signaling	Exit signaling mode
(config-vpls)#commit	Commit the transaction.

RTR4: Interface

(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe2	Enter the Interface mode for xe2
(config-if)#switchport	Enable switchport on the interface
(config-if)#mpls-vpls vpls1 service template st1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#commit	Commit the transaction.

Virtual Circuit Configuration**RTR1: Global VC Configuration**

(config)#mpls l2-circuit t1 100 44.44.44.44	Enter the VC configuration command in router mode.
(config-pseudowire)#exit	Exit service template mode
(config)#bridge 1 protocol ieee vlan-bridge	Creating a VLAN-bridge in router mode.
(config)#commit	Commit the transaction.

RTR1: Interface Configuration

(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template configuration
(config)#interface xe1	Enter interface mode for xe1.
(config-if)#switchport	Enable switchport on the interface.
(config-if)#mpls-vpls vpls1 service-template st1	Bind the interface to VPLS.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if)#commit	Commit the transaction.

RTR4: Global VC Configuration

(config)#mpls l2-circuit t1 100 11.11.11.11	Enter the VC configuration command in router mode.
(config)#exit	Exit service template mode.
(config)#bridge 1 protocol ieee vlan-bridge	Creating a VLAN-bridge in router mode.
(config)#commit	Commit the transaction.

RTR4: Interface Configuration

(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe2	Enter interface mode for xe2.
(config-if)#switchport	Enable switchport on the interface.
(config-if)#mpls-vpls vpls1 service-template st1	Bind the interface to VPLS.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config)#commit	Commit the transaction.

VPLS Configuration**RTR1: Global VPLS Configuration**

(config)#mpls vpls vpls1 1	Enter the VPLS configuration mode.
(config-vpls)#signaling ldp	Use LDP signaling for VPLS.
(config-vpls-sig)#vpls-peer 44.44.44.44	Configure RTR4 as VPLS peer for RTR1.
(config-vpls-sig)#exit-signaling	Exit signaling mode.
(config-vpls)#commit	Commit the transaction.

RTR1: Interface Configuration

(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe1	Enter interface mode for xe1.
(config-if)#switchport	Enable switchport on the interface.
(config-if)#mpls-vpls vpls1 service-template st1	Bind the interface to VPLS.
(config-if-vpls)#commit	Commit the transaction.

RTR4: Global VC Configuration

(config)#mpls vpls vpls1 1	Enter the VPLS configuration mode.
(config-vpls)#signaling ldp	Use LDP signaling for VPLS.
(config-vpls-sig)#vpls-peer 11.11.11.11	Configure RTR4 as VPLS peer for RTR1.

(config-vpls-sig) #exit-signaling	Exit signaling mode.
(config-vpls) #commit	Commit the transaction.

RTR4: Interface Configuration

(config) #service-template st1	Template configuration
(config-svc) #exit	Exit service template mode
(config) #interface xe2	Enter interface mode for xe2.
(config-if) #switchport	Enable switchport on the interface.
(config-if) #mpls-vpls vpls1 service-template st1	Bind the interface to VPLS.
(config-if-vpls) #exit	Exit VPLS mode and return to interface mode.
(config-if) #commit	Commit the transaction.

Configure RSVP-LSP

RTR1: Global RSVP configuration

#configure terminal	Enter configure mode.
(config) #router rsvp	Enter RSVP configuration mode for the router.
(config-router) #commit	Commit the transaction.

RTR1: Enabling RSVP and label switching on interface

(config) #interface xe2	Enter interface mode for xe2.
(config-if) #enable-rsvp	Enable RSVP on the interface.
(config-if) #label-switching	Enable Label switching on the interface.
(config-if) #commit	Commit the transaction.

RTR1: Trunk Configuration

(config) #rsvp-trunk t1	Configure RSVP trunk t1
(config-trunk) #to 44.44.44.44	Configure RTR4 as the end of trunk
(config-trunk) #commit	Commit the transaction.

RTR2: Global RSVP configuration

(config) #router rsvp	Enter RSVP configuration mode for the router.
(config-router) #php	Configure PHP on the end node.
(config-router) #commit	Commit the transaction.

RTR2: Enabling RSVP and label switching on interface

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode for xe2.
(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#commit	Commit the transaction.

RTR3: Global RSVP configuration

#configure terminal	Enter configure mode.
(config)#router rsvp	Enter RSVP configuration mode for the router.
(config-router)#php	Configure PHP on the end node.
(config-router)#commit	Commit the transaction.

RTR3: Enabling RSVP and label switching on interface

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode for xe3.
(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#commit	Commit the transaction.

RTR4: Global RSVP configuration

#configure terminal	Enter configure mode.
(config)#router rsvp	Enter RSVP configuration mode for the router.
(config-router)#commit	Commit the transaction.

RTR4: Enabling RSVP and label switching on interface

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#commit	Commit the transaction.

RTR4: Trunk Configuration

(config)#rsvp-trunk t2	Configure RSVP trunk t2.
(config-trunk)#to 11.11.11.11	Configure RTR1 as the end of trunk.
(config-trunk)#commit	Commit the transaction.

Configure Static-LSP**RTR1: Global Static configuration**

(config)#mpls ftn-entry 44.44.44.44/32 100 10.10.10.2 xe1	Configure FTN entry for rtr4 loopback.
(config)#mpls ilm-entry 900 pop	Pop the incoming label
(config)#commit	Commit the transaction.

RTR1: Enabling label switching on interface

(config)#interface xe2	Enter interface mode for xe2.
(config-if)#label-switching	Enable Label switching on the interface.
(config)#commit	Commit the transaction.

RTR2: Global Static configuration

mpls ilm-entry 100 swap 200 xe2 20.20.20.2 44.44.44.44/32	Swap the incoming label
mpls ilm-entry 800 swap 900 xe1 10.10.10.1 11.11.11.11/32	Swap the incoming label

RTR2: Enabling label switching on interface

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode for xe2.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#commit	Commit the transaction.

RTR3: Global Static configuration

(config)#mpls ilm-entry 200 swap 300 xe2 30.30.30.2 44.44.44.44/32	Swap the incoming label
(config)#mpls ilm-entry 700 swap 800 xe1 20.20.20.1 11.11.11.11/32	Swap the incoming label
(config)#commit	Commit the transaction.

RTR3: Enabling label switching on interface

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode for xe3.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#commit	Commit the transaction.

RTR4: Global Static configuration

(config)#mpls ftn-entry 11.11.11.11/32 700 30.30.30.1 xe1	Configure FTN entry for RTR1 loopback.
(config)mpls ilm-entry 300 pop	Pop the incoming label.
(config)#commit	Commit the transaction.

RTR4: Enabling label switching on interface

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#commit	Commit the transaction.

Validation

Here, 1000 packets are transmitted between the PE nodes and the output of counters at each node is mentioned below.

For Static-LSP

```

RTR1#show mpls counters static
[FTN statistics]
+-----+-----+-----+-----+
|          FEC          | out-label | Tx packets | Tx bytes |
+-----+-----+-----+-----+
| 44.44.44.44/32       | 100       | 49939      | 807798   |
+-----+-----+-----+-----+
[ILM statistics]
+-----+-----+-----+-----+
| bytes  FEC  | in-label | out-label | Rx packets | Rx
|-----|-----|-----|-----|
| bytes  | Tx packets | Tx bytes |          |
+-----+-----+-----+-----+
| 0.0.0.0/0      | 900      | n/a       | 40546     | 3486956
| n/a           | n/a      |           |           |
RTR1#

```

```

RTR2#show mpls counters static
[FTN statistics]

```

```

+-----+-----+-----+-----+
|          FEC          | out-label |      Tx packets      |      Tx bytes      |
+-----+-----+-----+-----+

[ILM statistics]
+-----+-----+-----+-----+
--
-----+-----+-----+-----+
|          FEC          | in-label  | out-label |      Rx packets      |      Rx
bytes    |      Tx packets      |      Tx bytes      |
+-----+-----+-----+-----+
--
-----+-----+-----+-----+
44.44.44.44/32      100      200      9393      807798
9393      807798
11.11.11.11/32      800      900      40546      3486956
40546      3486956
RTR2#

```

RTR3#show mpls counters static

```

[FTN statistics]
+-----+-----+-----+-----+
|          FEC          | out-label |      Tx packets      |      Tx bytes      |
+-----+-----+-----+-----+

[ILM statistics]
+-----+-----+-----+-----+
--
-----+-----+-----+-----+
|          FEC          | in-label  | out-label |      Rx packets      |      Rx
bytes    |      Tx packets      |      Tx bytes      |
+-----+-----+-----+-----+
--
-----+-----+-----+-----+
44.44.44.44/32      200      300      9393      807798
9393      807798
11.11.11.11/32      700      800      40546      3486956
40546      3486956
RTR3#

```

RTR4#show mpls counters static

```

[FTN statistics]
+-----+-----+-----+-----+
|          FEC          | out-label |      Tx packets      |      Tx bytes      |
+-----+-----+-----+-----+
11.11.11.11/32      700      49939      3486956

[ILM statistics]
+-----+-----+-----+-----+
--
-----+-----+-----+-----+
|          FEC          | in-label  | out-label |      Rx packets      |      Rx
bytes    |      Tx packets      |      Tx bytes      |
+-----+-----+-----+-----+
--
-----+-----+-----+-----+
0.0.0.0/0      300      n/a      9393      807798

```

n/a
RTR4#

For RSVP-LSP

```
RTR1#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 44.44.44.44 Egress 11.11.11.11
  lsp-name : t1-Primary                                [Egress]
  lsp-ingress : 44.44.44.44      lsp-id : 2201
  Rx pkts : 2509072              Rx bytes : 187780192
  Tx pkts : 0                   Tx bytes : 0
```

```
Tunnel-id 5001 Extended Tunnel-ID 11.11.11.11 Egress 44.44.44.44
  lsp-name : t1-Primary                                [Ingress]
  lsp-ingress : 11.11.11.11      lsp-id : 2201
  Rx pkts : 0                  Rx bytes : 0
  Tx pkts : 5578405           Tx bytes : 451417492
```

```
RTR2#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 44.44.44.44 Egress 11.11.11.11
  lsp-name : t1-Primary                                [Transit]
  lsp-ingress : 44.44.44.44      lsp-id : 2201
  Rx pkts : 2565947              Rx bytes : 192671442
  Tx pkts : 2565960              Tx bytes : 192672560
```

```
Tunnel-id 5001 Extended Tunnel-ID 11.11.11.11 Egress 44.44.44.44
  lsp-name : t1-Primary                                [Transit]
  lsp-ingress : 11.11.11.11      lsp-id : 2201
  Rx pkts : 5631460              Rx bytes : 456305560
  Tx pkts : 5631472              Tx bytes : 456306592
```

```
RTR3#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 44.44.44.44 Egress 11.11.11.11
  lsp-name : t1-Primary                                [Transit]
  lsp-ingress : 44.44.44.44      lsp-id : 2201
  Rx pkts : 2565947              Rx bytes : 282671442
  Tx pkts : 2565960              Tx bytes : 282672560
```

```
Tunnel-id 5001 Extended Tunnel-ID 11.11.11.11 Egress 44.44.44.44
  lsp-name : t1-Primary                                [Transit]
  lsp-ingress : 11.11.11.11      lsp-id : 2201
  Rx pkts : 8631460              Rx bytes : 457245560
  Tx pkts : 8631472              Tx bytes : 45724592
```

```
RTR4#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 44.44.44.44 Egress 11.11.11.11
  lsp-name : t1-Primary                                [Ingress]
  lsp-ingress : 44.44.44.44      lsp-id : 2201
  Rx pkts : 0                  Rx bytes : 0
  Tx pkts : 10231330           Tx bytes : 374371318
```

```
Tunnel-id 5001 Extended Tunnel-ID 11.11.11.11 Egress 44.44.44.44
  lsp-name : t1-Primary                                [Egress]
```

```

lsp-ingress : 11.11.11.11      lsp-id : 2201
Rx pkts : 5651207              Rx bytes : 458003802
Tx pkts : 0                    Tx bytes : 0

```

```

R3#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 44.44.44.44 Egress 11.11.11.11 lsp-name :
t1-Primary[Transit]
lsp-ingress : 44.44.44.44lsp-id : 2201
Rx pkts : 2565947Rx bytes : 282671442
Tx pkts : 2565960Tx bytes : 282672560

```

```

Tunnel-id 5001 Extended Tunnel-ID 11.11.11.11 Egress 44.44.44.44 lsp-name :
t1-Primary[Transit]
lsp-ingress : 11.11.11.11lsp-id : 2201
Rx pkts : 8631460Rx bytes : 457245560
Tx pkts : 8631472Tx bytes : 45724592

```

```

R4#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 44.44.44.44 Egress 11.11.11.11 lsp-name :
t1-Primary[Ingress]
lsp-ingress : 44.44.44.44lsp-id : 2201 Rx pkts : 0Rx bytes : 0
Tx pkts : 10231330Tx bytes : 374371318

```

```

Tunnel-id 5001 Extended Tunnel-ID 11.11.11.11 Egress 44.44.44.44 lsp-name :
t1-Primary[Egress]
lsp-ingress : 11.11.11.11lsp-id : 2201
Rx pkts : 5651207Rx bytes : 458003802
Tx pkts : 0Tx bytes : 0

```

For LDP-LSP

```

RTR1#show mpls counters ldp
[FTN statistics]
+-----+-----+-----+-----+
|          FEC          | out-label | Tx packets | Tx bytes |
+-----+-----+-----+-----+
| 44.44.44.44/32       | 52483    | 1000      | 1004000  |
+-----+-----+-----+-----+
[ILM statistics]
+-----+-----+-----+-----+-----+-----+
| FEC | in-label | out-label | Rx packets | Rx bytes | Tx packets | Tx bytes |
+-----+-----+-----+-----+-----+-----+

```

```

RTR2#show mpls counters ldp
[FTN statistics]
+-----+-----+-----+-----+
|          FEC          | out-label | Tx packets | Tx bytes |
+-----+-----+-----+-----+
[ILM statistics]
+-----+-----+-----+-----+-----+-----+
| FEC | in-label | out-label | Rx packets | Rx bytes | Tx packets | Tx bytes |
+-----+-----+-----+-----+-----+-----+
| 44.44.44.44/32       | 52483    | 52483    | 1000      | 1004000  | 1000      | 1004000  |
+-----+-----+-----+-----+-----+-----+

```

```

/RTR2#show mpls counters ldp [FTN statistics]
+-----+-----+-----+-----+
|          FEC          | out-label | Tx packets | Tx bytes |
+-----+-----+-----+-----+

```

```

+-----+-----+-----+-----+
[ILM statistics]
+-----+-----+-----+-----+-----+-----+
| FEC | in-label | out-label | Rx packets | Rx bytes | Tx packets | Tx bytes |
+-----+-----+-----+-----+-----+-----+
44.44.44.44/325248352483 1000100400010001004000

```

For LDP-VC

```

RTR1#show mpls l2-circuit t1 statistics
MPLS Layer-2 Virtual Circuit: t1, id 100

```

Access port statistics:

```

RX:  Input packets : 0
     Input bytes   : 0
TX:  Output packets : 4642811
     Output bytes  : 297139904

```

Network port statistics:

```

RX:  Input packets : 4642804
     Input bytes   : 399281144
TX:  Output packets : 0
     Output bytes  : 0

```

```

RTR4#show mpls l2-circuit t1 statistics
MPLS Layer-2 Virtual Circuit: t1, id 100

```

Access port statistics:

```

RX:  Input packets : 4633957
     Input bytes   : 296573248
TX:  Output packets : 0
     Output bytes  : 0

```

Network port statistics:

```

RX:  Input packets : 0
     Input bytes   : 0
TX:  Output packets : 4633960
     Output bytes  : 398520560

```

For LDP-VPLS

```

RTR1#show mpls vpls vpls1 statistics
Virtual Private LAN Service Instance: vpls1, ID: 1

```

Access port statistics:

Interface: xel

```

RX:  Input packets : 1922483
     Input bytes   : 123038912
TX:  Output packets : 3894242
     Output bytes  : 126192000

```

Network port statistics:

Mesh Peer: 44.44.44.44 (Up)

```

RX:  Input packets : 1971746
     Input bytes   : 169570156
TX:  Output packets : 3894244

```

Output bytes : 165334398

RTR4#show mpls vpls vpls1 statistics
Virtual Private LAN Service Instance: vpls1, ID: 1

Access port statistics:

Interface: xe2

RX: Input packets : 1967571
Input bytes : 125924544
TX: Output packets : 3885889
Output bytes : 122772032

Network port statistics:

Mesh Peer: 11.11.11.11 (Up)

RX: Input packets : 1918310
Input bytes : 164974660
TX: Output packets : 3885892
Output bytes : 169211622

CHAPTER 9 Anycast Gateway Routing for Multiple Subnets in EVPN-IRB

Overview

In the Ethernet VPN Integrated Routing and Bridging (EVPN-IRB) scenario, any two Layer 2 Virtual Network Identifiers (L2 VNID) nodes communicate using the Routing IP Virtual Routing and Forwarding (VRF). This communication is enriched with Anycast Gateway Routing to accommodate communication among multiple subnets under the IRB interface (per VNID).

In the current implementation, the router's primary IPv4 or IPv6 address is either Router Media Access Control (MAC) or Anycast MAC, and the secondary IPv4 or IPv6 address is always the Router MAC address. Hence, Anycast MAC support was only for the primary IP with a single subnet.

Additionally, the BGP router cannot establish a connection with the primary IP as it is in Anycast mode, and the TCP connection is possible only with any of the routers, as both the routes have the IP as Anycast.

To overcome this drawback, the feature is enhanced to configure both Router MAC or Anycast MAC for both primary and secondary subnets.

By default, each subnet uses the Router MAC address received from the ARP/ND cache. The `anycast` argument in `evpn irb-if forwarding anycast gateway` CLI is used to configure the Anycast MAC for primary or secondary subnets. The argument helps to update the ARP/ND cache with Anycast MAC. This enables the user to use Anycast MAC for multiple subnets under L2 VNID. For example, users can have Subnets A, B, C with Anycast MAC and Subnet D with Router MAC.

Feature Characteristics

This feature enhancement provides the following support:

- Enables configuration of either a Router MAC or an Anycast MAC address for primary or secondary subnets.
- Use of Anycast or Routing IP Gateway for multiple subnets under the Layer-2 VNID's.
- Flexibility to have Anycast Gateway for multiple subnets (for example, Subnet A, B, and C) while allowing the other subnet (for example, Subnet D) to be reserved for BGP.
- The InterfaceFull model that provides the flexibility to respond to the ARP/ND requests from the ARP/ND table.
- The InterfaceLess model that use the kernel interface with a unique MAC per interface, either Router MAC or Anycast MAC for all the subnets.

LIMITATIONS:

In InterfaceLess model, the kernel IRB interface has a single MAC that is either Router MAC or Anycast MAC, however, the response message always has Anycast MAC irrespective of whether the interface's IP address is Anycast or Router MAC.

Benefits

Allows users to have primary and secondary subnets with either Router MAC or Anycast MAC. This flexibility provides support for Anycast Gateway for multiple subnets under Layer 2 VNIDs.

Configuration

Following configuration illustrates how to use the `anycast` argument in `evpn irb-if` forwarding `anycast gateway` CLI to configure the Anycast MAC for both primary or secondary subnets.

Topology

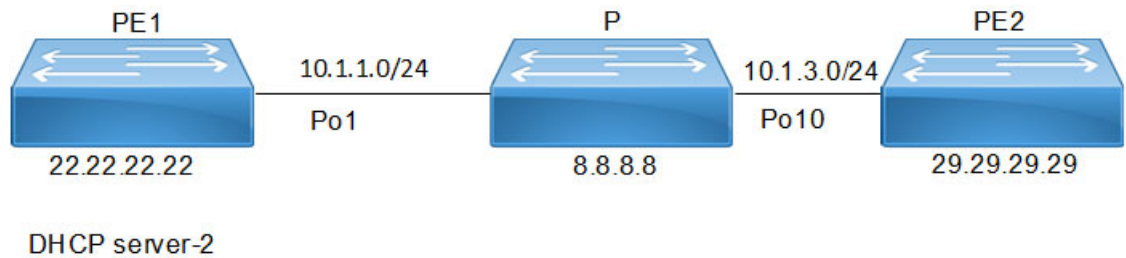


Figure 9-1: Anycast Gateway support for subnets

PE1 Configuration

PE1: Loopback Interface

PE1(config)#interface lo	Enter the loopback interface mode.
PE1(config-if)#ip address 22.22.22.22/32 secondary	Configure the IP address on loopback interface.
PE1(config-if)#ip router isis ISIS-100	Enable the IS-IS routing on an interface for area 49 (ISIS-100).
PE1(config-if)#enable-ldp ipv4	Enable the LDP IPv4.
PE1(config-if)#Commit	Commit the configurations
PE1(config-if)#exit	Exit the configuration mode.

PE1: Global LDP

PE1(config)#router ldp	Enter the Router LDP mode.
PE1(config-router)#router-id 22.22.22.22	Enter the LDP router-id.
PE1(config-router)#targeted-peer ipv4 29.29.29.29	Configure the LDP target peer address.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted peer mode.

PE1(config-router)#transport-address ipv4 22.22.22.22	Configure the LDP transport address.
PE1(config-router)#Commit	Commit the configurations
PE1(config-router)#exit	Exit the configuration mode.

PE1: Interface Configuration on Network Side

PE1(config)#interface po1	Enter the Interface mode for the port channel interface
PE1(config-if)#ip address 10.1.1.22/24	Configure the IP address on port channel interface
PE1(config-if)#label-switching	Enable the label switching
PE1(config-if)#ip router isis ISIS-100	Enable the IS-IS routing on an interface for area 49 (ISIS-100)
PE1(config-if)#enable-ldp ipv4	Enable the LDP IPv4
PE1(config-if)#interface xe22	Enter interface mode
PE1(config-if)#channel-group 1 mode active	Moving interface to Dynamic LAG 1
PE1(config-if)#Commit	Commit the configurations
PE1(config-if)#exit	Exit the configuration mode.

PE1: IGP-ISIS Configuration

PE1(config)#router isis ISIS-100	Create an ISIS routing instance for area 49 (ISIS-100).
PE1(config-router)#is-type level-1	Configure instance as level-1 routing.
PE1(config-router)#metric-style wide	Configure the new style of metric type as wide.
PE1(config-router)#mpls traffic-eng router-id 22.22.22.22	Configure MPLS-TE unique router-id TLV.
PE1(config-router)#mpls traffic-eng level-1	Enable the MPLS-TE in is-type Level-1.
PE1(config-router)#capability cspf	Enable the Constrained Shortest Path First (CSPF).
PE1(config-router)#dynamic-hostname	Configure the host name to be advertised for an ISIS instance.
PE1(config-router)#net 49.0001.0000.0000.0001.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
PE1(config-router)#Commit	Commit the configurations
PE1(config-router)#exit	Exit the configuration mode.

PE1: BGP Configuration

PE1(config)#router bgp 65535	Enter into Router BGP mode.
PE1(config-router)#bgp router-id 22.22.22.22	Configure router-id as 22.22.22.22 (loopback ip address).
PE1(config-router)#neighbor 29.29.29.29 remote-as 65535	Configuring PE2 as iBGP neighbor using it's loopback IP.
PE1(config-router)#neighbor 29.29.29.29 update- source lo	Source of routing updates as loopback.
PE1(config-router)#neighbor 29.29.29.29 advertisement-interval 0	Configure advertisement-interval as 0 for fast convergence for PE2

PE1(config-router)#address-family l2vpn evpn	Enter into l2vpn EVPN address family mode.
PE1(config-router-af)#neighbor 29.29.29.29 active	Enabling EVPN Address family for neighbor.
PE1(config-router-af)#exit-address-family	Exiting of Address family mode.
PE1(config-router)#address-family ipv4 vrf ip_vrf205_mgmt	Entering into VRF address family mode.
PE1(config-router-af)#redistribute connected	Redistribute connected routes to the network.
PE1(config-router-af)#exit-address-family	Exiting of Address family mode.
PE1(config-router)#Commit	Commit the configurations
PE1(config-router)#exit	Exit the configuration mode.

PE1: Global EVPN MPLS Command

PE1(config)#evpn mpls enable	Enable the EVPN MPLS globally.
PE1(config)#evpn mpls irb	Enable the EVPN MPLS IRB globally.
PE1(config)#evpn mpls multihoming enable	Enable the Multi homing, save configures and reboot the board for multi homing to be effective.
PE1(config)#qos enable	Enable the QOS.
PE1(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.4455	Configure anycast gateway MAC globally.
PE1(config)#evpn mpls vtep-ip-global 22.22.22.22	Configure VTEP global IP.
PE1(config)#Commit	Commit the configurations
PE1(config)#exit	Exit the configuration mode.

PE1: MAC VRF Configuration

PE1(config)#mac vrf vrf205_mgmt	Enter Mac VRF mode.
PE1(config-vrf)#rd 22.22.22.22:205	Configuring Route-Distinguisher value.
PE1(config-vrf)#route-target both evpn-auto-rt	Configuring import and export value as evpn-auto-rt. Route targets will be derived automatically.
PE1(config-vrf)#Commit	Commit the configurations
PE1(config-vrf)#exit	Exit the configuration mode.

PE1: IP VRF Configuration

PE1(config)#ip vrf ip_vrf205_mgmt	Enter IP VRF mode
PE1(config-vrf)#rd 22.22.22.22:305	Configuring Route-Distinguisher value
PE1(config-vrf)#route-target both 305:305	Configuring route target values i.e import and export values
PE1(config-vrf)#l3vni 305	Configure L3 VNID for routing
PE1(config-vrf)#Commit	Commit the configurations
PE1(config-vrf)#exit	Exit the configuration mode.

PE1: IRB Interface Configuration with multiple IPs

PE1(config)#interface irb127	Create IRB interface irb127
PE1(config-irb-if)#ip vrf forwarding ip_vrf205_mgmt	Bind the VRF instance to the interface
PE1(config-irb-if)#evpn irb-if-forwarding anycast-gateway-mac	Enable an IRB interface to use the global anycast IRB mac-address
PE1(config-irb-if)#ip address 98.98.101.1/24 anycast	Configure the IPv4 primary address and use anycast mac address
PE1(config-irb-if)#ip address 103.103.102.1/24 secondary	Configure secondary IPv4 secondary address
PE1(config-irb-if)#ip address 104.104.103.1/24 secondary anycast	Configure secondary IPv4 secondary address and use as anycast mac address
PE1(config-irb-if)#Commit	Commit the configurations
PE1(config-irb-if)#exit	Exit the configuration mode.

PE1: EVPN MPLS Id Configuration

PE1(config)#evpn mpls id 127	Configure secondary IPv4 secondary address
PE1(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf205_mgmt	Map the MAC VRF red
PE1(config-evpn-mpls)#evpn irb irb127	Map the IRB interface
PE1(config-evpn-mpls)#commit	Commit the configurations
PE1(config-evpn-mpls)#exit	Exit the configuration mode.

PE1: Interface Configuration on Access Side

PE1(config)#interface xe72.127 switchport	Creating L2 sub interface of physical interface xe72
PE1(config-if)#encapsulation dot1q 127	Setting Encapsulation to dot1q with VLAN ID 127 Supported Encapsulation: dot1ad, dot1q, untagged, default
PE1(config-if)#rewrite pop	Configure rewrite with action pop
PE1(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
PE1(config-acc-if-evpn)#map vpn-id 127	Map VPN-ID 127
PE1(config-acc-if-evpn)#Commit	Commit the configurations
PE1(config-acc-if-evpn)#exit	Exit the configuration mode.

P Configuration**P: Loopback Interface**

P(config)#interface lo	Enter the Interface mode for the loopback interface.
P(config-if)#ip address 8.8.8.8/32 secondary	Configure the IP address on loopback interface.
P(config-if)#ip router isis ISIS-100	Enable the IS-IS routing on an interface for area 49 (ISIS-100).
P(config-if)#enable-ldp ipv4	Enable the LDP IPv4.
P(config-if)#Commit	Commit the configurations
P(config-if)#exit	Exit the configuration mode.

P: Global LDP

P(config)#router ldp	Enter the Router LDP mode.
P(config-router)#router-id 8.8.8.8	Enter the LDP router-id.
P(config-router)#transport-address ipv4 8.8.8.8	Configure the LDP transport address.
P(config-router)#Commit	Commit the configurations
P(config-router)#exit	Exit the configuration mode.

P: Interface Configuration on Network Side

P(config)#interface po1	Enter the Interface mode for the port channel interface.
P(config-if)#ip address 10.1.1.8/24	Configure the IP address on port channel interface.
P(config-if)#label-switching	Enable the label switching.
P(config-if)#ip router isis ISIS-100	Enable the IS-IS routing on an interface for area 49 (ISIS-100).
P(config-if)#enable-ldp ipv4	Enable the LDP IPv4.
P(config-if)#Commit	Commit the configurations
P(config-if)#exit	Exit the configuration mode.
P(config)#interface xe22	Enter interface mode.
P(config-if)#channel-group 1 mode active	Moving interface to Dynamic LAG 1.
P(config-if)#Commit	Commit the configurations
P(config-if)#exit	Exit the configuration mode.
P(config)#interface po10	Enter the Interface mode for the port channel interface.
P(config-if)#ip address 10.1.3.8/24	Configure the IP address on port channel interface.
P(config-if)#label-switching	Enable the label switching.
P(config-if)#ip router isis ISIS-100	Enable the IS-IS routing on an interface for area 49 (ISIS-100).
P(config-if)#enable-ldp ipv4	Enable the LDP IPv4.
P(config-if)#interface xe10	Enter interface mode.
P(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10.
P(config-if)#Commit	Commit the configurations
P(config-if)#exit	Exit the configuration mode.

P: IGP-ISIS Configuration

P(config)#router isis ISIS-100	Create an IS-IS routing instance for area 49 (ISIS-100).
P(config-router)#is-type level-1	Configure the instance as level-1 routing.
P(config-router)#metric-style wide	Configure the new style of metric type as wide.
P(config-router)#mpls traffic-eng router-id 8.8.8.8	Configure MPLS-TE unique router-id TLV.
P(config-router)#mpls traffic-eng level-1	Enable the MPLS-TE in is-type Level-1.
P(config-router)#capability cspf	Enable the CSPF (Constrained Shortest Path First).
P(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.

P(config-router)#net 49.0001.0000.0000.0002.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
P(config-router)#Commit	Commit the configurations
P(config-router)#exit	Exit the configuration mode.

PE2 Configuration

PE2: Loopback Interface

PE2(config)#interface lo	Enter the Interface mode for the loopback interface.
PE2(config-if)#ip address 29.29.29.29/32 secondary	Configure the IP address on loopback interface.
PE2(config-if)#ip router isis ISIS-100	Enable the IS-IS routing on an interface for area 49 (ISIS-100).
PE2(config-if)#enable-ldp ipv4	Enable the LDP IPv4.
PE2(config-if)#Commit	Commit the configurations
PE2(config-if)#exit	Exit the configuration mode.

PE2: Global LDP

PE2(config)#router ldp	Enter the Router LDP mode.
PE2(config-router)#router-id 29.29.29.29	Enter the LDP router-id.
PE2(config-router)#targeted-peer ipv4 22.22.22.22	Configure the LDP target peer address.
PE2(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted peer mode.
PE2(config-router)#transport-address ipv4 29.29.29.29	Configure the LDP transport address.
PE2(config-router)#Commit	Commit the configurations
PE2(config-router)#exit	Exit the configuration mode.

PE2: Global LDP

PE2(config)#router ldp	Enter the Router LDP mode.
PE2(config-router)#router-id 29.29.29.29	Enter the LDP router-id.
PE2(config-router)#targeted-peer ipv4 22.22.22.22	Configure the LDP target peer address.
PE2(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted peer mode.
PE2(config-router)#transport-address ipv4 29.29.29.29	Configure the LDP transport address.
PE2(config-router)#Commit	Commit the configurations
PE2(config-router)#exit	Exit the configuration mode.

PE2: Interface Configuration on Network Side

PE2(config)#interface po10	Enter the Interface mode for the port channel interface.
PE2(config-if)#ip address 10.1.3.29/24	Configure the IP address on port channel interface.
PE2(config-if)#label-switching	Enable the label switching.
PE2(config-if)#ip router isis ISIS-100	Enable the IS-IS routing on an interface for area 49 (ISIS-100).
PE2(config-if)#enable-ldp ipv4	Enable the LDP IPv4.
PE2(config-if)#interface ge1	Enter interface mode.

PE2(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10.
PE2(config-if)#Commit	Commit the configurations
PE2(config-if)#exit	Exit the configuration mode.

PE2: IGP-ISIS Configuration

PE2(config)#router isis ISIS-100	Create an IS-IS routing instance for area 49 (ISIS-100).
PE2(config-router)#is-type level-1	Configure instance as level-1 routing.
PE2(config-router)#metric-style wide	Configure the new style of metric type as wide.
PE2(config-router)#mpls traffic-eng router-id 29.29.29.29	Configure MPLS-TE unique router-id TLV.
PE2(config-router)#mpls traffic-eng level-1	Enable the MPLS-TE in is-type Level-1.
PE2(config-router)#capability cspf	Enable the CSPF (Constrained Shortest Path First).
PE2(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
PE2(config-router)#net 49.0001.0000.0000.0029.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
PE2(config-router)#Commit	Commit the configurations
PE2(config-router)#exit	Exit the configuration mode.

PE2: BGP Configuration

PE2(config)#router bgp 65535	Enter into Router BGP mode.
PE2(config-router)#bgp router-id 29.29.29.29	Configure router-id as 29.29.29.29 (loopback ip address).
PE2(config-router)#neighbor 22.22.22.22 remote-as 65535	Configuring PE2 as iBGP neighbor using it's loopback IP.
PE2(config-router)#neighbor 22.22.22.22 update- source lo	Source of routing updates as loopback.
PE2(config-router)#neighbor 22.22.22.22 advertisement-interval 0	Configure advertisement-interval as 0 for fast convergence for PE2.
PE2(config-router)#address-family l2vpn evpn	Enter into l2vpn EVPN address family mode.
PE2(config-router-af)#neighbor 22.22.22.22 active	Enabling EVPN Address family for neighbor.
PE2(config-router-af)#exit-address-family	Exiting of Address family mode.
PE2(config-router)#address-family ipv4 vrf ip_vrf205_mgmt	Entering into VRF address family mode.
PE2(config-router-af)#redistribute connected	Redistribute connected routes to the network.
PE2(config-router-af)#exit-address-family	Exiting of Address family mode.
PE2(config-router-af)#commit	Commit the configurations
PE2(config-router-af)#exit	Exit the configuration mode.

PE2: Global EVPN MPLS Command

PE2(config)#evpn mpls enable	Enable the EVPN MPLS globally.
PE2(config)#evpn mpls irb	Enable the EVPN MPLS IRB globally.
PE2(config)#evpn mpls multihoming enable	Enable the Multihoming, save configs and reboot the board for multihoming to be effective.
PE2(config)#qos enable	Enable the QOS.

PE2(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.4567	Configure anycast gateway MAC globally.
PE2(config)#evpn mpls vtep-ip-global 29.29.29.29	Configure VTEP global IP.
PE2(config)#Commit	Commit the configurations
PE2(config)#exit	Exit the configuration mode.

PE2: MAC VRF Configuration

PE2(config)#mac vrf vrf205_mgmt	Enter Mac VRF mode.
PE2(config-vrf)#rd 29.29.29.29:205	Configuring Route-Distinguisher value.
PE2(config-vrf)#route-target both evpn-auto-rt	Configuring import and export value as evpn-auto-rt. Route target will be derived automatically.
PE2(config-vrf)#Commit	Commit the configurations
PE2(config-vrf)#exit	Exit the configuration mode.

PE2: IP VRF Configuration

PE2(config)#ip vrf ip_vrf205_mgmt	Enter IP VRF mode.
PE2(config-vrf)#rd 29.29.29.29:305	Configuring Route-Distinguisher value.
PE2(config-vrf)#route-target both 305:305	Configuring route target values i.e import and export values.
PE2(config-vrf)#l3vni 305	Configure L3 VNID for routing.
PE2(config-vrf)#Commit	Commit the configurations
PE2(config-vrf)#exit	Exit the configuration mode.

PE2: IRB Interface Configuration with multiple IPs

PE2(config)#interface irb127	Create IRB interface irb127.
PE2(config-irb-if)#ip vrf forwarding ip_vrf205_mgmt	Bind the VRF instance to the interface.
PE2(config-irb-if)#evpn irb-if-forwarding anycast-gateway-mac	Enable an IRB interface to use the global anycast IRB mac-address.
PE2(config-irb-if)#ip address 99.99.101.1/24 anycast	Configure the IPv4 primary address and use anycast mac address.
PE2(config-irb-if)#ip address 103.103.103.1/24 secondary	Configure secondary IPv4 secondary address.
PE2(config-irb-if)#ip address 104.104.104.1/24 secondary anycast	Configure secondary IPv4 secondary address and use as anycast mac address.
PE2(config-irb-if)#Commit	Commit the configurations
PE2(config-irb-if)#exit	Exit the configuration mode.

PE2: EVPN MPLS Id Configuration

PE2(config)#evpn mpls id 127	Configure secondary IPv4 secondary address.
PE2(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf205_mgmt	Map the MAC VRF red.
PE2(config-evpn-mpls)#evpn irb irb127	Map the IRB interface.
PE2(config-evpn-mpls)#commit	Commit the configurations
PE2(config-evpn-mpls)#exit	Exit the configuration mode.

PE2: Interface Configuration on Access Side

PE2(config)#interface xe12.127 switchport	Creating L2 sub interface on physical interface xe12.
PE2(config-if)#encapsulation dot1q 127	Setting Encapsulation to dot1q with VLAN ID 127 Supported Encapsulation: dot1ad, dot1q, untagged, default.
PE2(config-if)#rewrite pop	Configure rewrite with action pop.
PE2(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration.
PE2(config-acc-if-evpn)#map vpn-id 127	Map VPN-ID 127.
PE2(config-acc-if-evpn)#Commit	Commit the configurations
PE2(config-acc-if-evpn)#exit	Exit the configuration mode.

Validation

Verify installed EVPN MPLS tunnels information.

PE1:

```
#show evpn mpls
EVPN-MPLS Information
=====
```

```
Codes: NW - Network Port
       AC - Access Port
       (u) - Untagged
```

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-Status	Src-Addr	Dst-Addr
127	----	L2	NW	----	----	----	----	22.22.22.22	29.29.29.29
127	----	--	AC	xe72.127	--- Single Homed Port ---	----	----	----	----

PE2:

```
#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source          Destination      Status          Up/Down         Update          evpn-id
=====
22.22.22.22     29.29.29.29     Installed     11:40:31       11:40:31       127
```

Verify the MAC addresses that are cached in the EVPN MAC and ARP table.

Verify the Anycast Gateway MAC addresses that are updated when configuring subnets with Anycast MAC:

PE1 verification:

```
#show evpn mpls mac-table
```

```
=====
EVPN MPLS MAC Entries
=====
```

VNID	Interface	VlanId	In-VlanId	Mac-Addr	VTEP-IP/ESI	Type	Status	MAC move
AccessPortDesc								
127	irb127	----	----	0011.2233.4455	22.22.22.22	Static Local	-----	0
127	irb127	----	----	e49d.73b3.c101	22.22.22.22	Static Local	-----	0
127	----	----	----	0011.2233.4567	29.29.29.29	Static Remote	-----	0
127	----	----	----	e8c5.7aff.96de	29.29.29.29	Static Remote	-----	0

Total number of entries are 4

```
#show evpn mpls arp-cache
```

MPLS-EVPN ARP-CACHE Information

=====

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
127	98.98.101.1	0011.2233.4455	Static Local	----	
127	99.99.101.1	0011.2233.4567	Static Remote	----	
127	103.103.102.1	e49d.73b3.c101	Static Local	----	
127	103.103.103.1	e8c5.7aff.96de	Static Remote	----	
127	104.104.103.1	0011.2233.4455	Static Local	----	
127	104.104.104.1	0011.2233.4567	Static Remote	----	

Total number of entries are 6

PE2 verification:

```
#show evpn mpls mac-table
```

=====

EVPN MPLS MAC Entries									
=====									
AccessPortDesc	Interface	VlanId	In-VlanId	Mac-Addr	VTEP-IP/ESI	Type	Status	MAC	move
127	----	----	----	0011.2233.4455	22.22.22.22	Static Remote	-----	0	-----
127	irb127	----	----	0011.2233.4567	29.29.29.29	Static Local	-----	0	-----
127	----	----	----	e49d.73b3.c101	22.22.22.22	Static Remote	-----	0	-----
127	irb127	----	----	e8c5.7aff.96de	29.29.29.29	Static Local	-----	0	-----

Total number of entries are : 4

```
#show evpn mpls arp-cache
```

MPLS-EVPN ARP-CACHE Information

=====

ARP Timeout : 180 sec Random-Jitter-Max : 200

EVPN-ID	Ip-Addr	Mac-Addr	Type	Age-Out	Retries-Left
127	98.98.101.1	0011.2233.4455	Static Remote	----	
127	99.99.101.1	0011.2233.4567	Static Local	----	
127	103.103.102.1	e49d.73b3.c101	Static Remote	----	
127	103.103.103.1	e8c5.7aff.96de	Static Local	----	
127	104.104.103.1	0011.2233.4455	Static Remote	----	
127	104.104.104.1	0011.2233.4567	Static Local	----	

Verify EVPN route count information as per VPN-ID or Route type:

PE1 verification:

```
#show evpn mpls route-count
```

EVPN-MPLS Active route count information

=====

Max supported route count : 131072

Active route count: 8

VNID	Total	MACONLY	MACIPv4	MACIPv6
------	-------	---------	---------	---------

```
-----
127          8          0          6          2
```

PE2 verification:

```
#show evpn mpls route-count
EVPN-MPLS Active route count information
```

```
=====
Max supported route count   : 131072
Active route count: 8
```

```
-----
VNID      Total      MACONLY  MACIPv4  MACIPv6
-----
127          8          0          6          2
```

Verify in the BGP EVPN table:**PE1 Verification:**

```
#show bgp l2vpn evpn
BGP table version is 2, local router ID is 22.22.22.22
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
```

```
l - labeled, S Stale
```

```
Origin codes: i - IGP, e - EGP, ? - incomplete
```

```
[EVPN route type]:[ESI]:[VNID]:[relevant route information]
```

- 1 - Ethernet Auto-discovery Route
- 2 - MAC/IP Route
- 3 - Inclusive Multicast Route
- 4 - Ethernet Segment Route
- 5 - Prefix Route

Network	Next Hop	Metric	LocPrf	Weight	Path	Peer	Encap
RD[10:200]							
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[17]	29.29.29.29	0	100	0	?	29.29.29.29	MPLS
RD[20:200]							
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	10.10.10.10	0	100	0	?	10.10.10.10	MPLS
RD[10.10.10.10:123]							
*>i [2]:[0]:[123]:[48,0011:2233:4567]:[32,99.99.99.1]:[22]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>i [3]:[123]:[32,10.10.10.10]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
RD[10.10.10.10:124]							
*>i [2]:[0]:[124]:[48,0011:2233:4567]:[32,99.99.100.1]:[24]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>i [3]:[124]:[32,10.10.10.10]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
RD[10.10.10.10:125]							
*>i [2]:[0]:[125]:[48,0011:2233:4567]:[32,88.88.3.1]:[21]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>i [3]:[125]:[32,10.10.10.10]							


```

10.10.10.10      0      100      0      i  10.10.10.10      MPLS

RD[10.10.10.10:126]
*>i  [3]:[126]:[32,10.10.10.10]
10.10.10.10      0      100      0      i  10.10.10.10      MPLS

RD[10.10.10.10:205]
*>i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[26]
10.10.10.10      0      100      0      i  10.10.10.10      MPLS
*>i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]
10.10.10.10      0      100      0      i  10.10.10.10      MPLS
*>i  [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1]:[26]
10.10.10.10      0      100      0      i  10.10.10.10      MPLS
*>i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
10.10.10.10      0      100      0      i  10.10.10.10      MPLS
*>i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1]:[26]
10.10.10.10      0      100      0      i  10.10.10.10      MPLS
*>i  [3]:[127]:[32,10.10.10.10]
10.10.10.10      0      100      0      i  10.10.10.10      MPLS

RD[10.10.10.10:305]
*>i  [5]:[0]:[0]:[24]:[99.99.101.0]:[0.0.0.0]:[17]
10.10.10.10      0      100      0      ?  10.10.10.10      MPLS
*>i  [5]:[0]:[0]:[24]:[103.103.103.0]:[0.0.0.0]:[17]
10.10.10.10      0      100      0      ?  10.10.10.10      MPLS
*>i  [5]:[0]:[0]:[24]:[104.104.104.0]:[0.0.0.0]:[17]
10.10.10.10      0      100      0      ?  10.10.10.10      MPLS

RD[10.10.10.10:333]
*>i  [5]:[0]:[0]:[24]:[99.99.99.0]:[0.0.0.0]:[19]
10.10.10.10      0      100      0      ?  10.10.10.10      MPLS

RD[10.10.10.10:334]
*>i  [5]:[0]:[0]:[24]:[99.99.100.0]:[0.0.0.0]:[18]
10.10.10.10      0      100      0      ?  10.10.10.10      MPLS

RD[10.10.10.10:500]
*>i  [3]:[500]:[32,10.10.10.10]
10.10.10.10      0      100      0      i  10.10.10.10      MPLS

RD[22.22.22.22:123] VRF[vrf100_mgmt]:
*>  [2]:[0]:[123]:[48,0011:2233:4455]:[32,98.98.98.1]:[25618]
22.22.22.22      0      100      32768  i  -----      MPLS
* i  [2]:[0]:[123]:[48,0011:2233:4567]:[32,99.99.99.1]:[28]
29.29.29.29      0      100      0      i  29.29.29.29      MPLS
* i  10.10.10.10      0      100      0      i  10.10.10.10      MPLS
* i  [3]:[123]:[32,10.10.10.10]
10.10.10.10      0      100      0      i  10.10.10.10      MPLS
*>  [3]:[123]:[32,22.22.22.22]
22.22.22.22      0      100      32768  i  -----      MPLS
* i  [3]:[123]:[32,29.29.29.29]
29.29.29.29      0      100      0      i  29.29.29.29      MPLS

RD[22.22.22.22:124] VRF[vrf200_mgmt]:
*>  [2]:[0]:[124]:[48,0011:2233:4455]:[32,98.98.99.1]:[25619]
22.22.22.22      0      100      32768  i  -----      MPLS
* i  [2]:[0]:[124]:[48,0011:2233:4567]:[32,99.99.100.1]:[29]
29.29.29.29      0      100      0      i  29.29.29.29      MPLS
* i  10.10.10.10      0      100      0      i  10.10.10.10      MPLS
* i  [3]:[124]:[32,10.10.10.10]
10.10.10.10      0      100      0      i  10.10.10.10      MPLS
*>  [3]:[124]:[32,22.22.22.22]
22.22.22.22      0      100      32768  i  -----      MPLS
* i  [3]:[124]:[32,29.29.29.29]
29.29.29.29      0      100      0      i  29.29.29.29      MPLS

RD[22.22.22.22:125] VRF[vrf201_mgmt]:
*>  [2]:[0]:[125]:[48,0011:2233:4455]:[32,88.88.1.1]:[25629]
22.22.22.22      0      100      32768  i  -----      MPLS
* i  [2]:[0]:[125]:[48,0011:2233:4567]:[32,88.88.3.1]:[37]
29.29.29.29      0      100      0      i  29.29.29.29      MPLS
* i  10.10.10.10      0      100      0      i  10.10.10.10      MPLS
* i  [3]:[125]:[32,10.10.10.10]

```

```

10.10.10.10      0      100      0      i  10.10.10.10      MPLS
*>  [3]:[125]:[32,22.22.22.22]
      22.22.22.22      0      100      32768      i  -----      MPLS
* i  [3]:[125]:[32,29.29.29.29]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS

RD[22.22.22.22:126] VRF[vrf202_mgmt]:
* i  [3]:[126]:[32,10.10.10.10]
      10.10.10.10      0      100      0      i  10.10.10.10      MPLS
*>  [3]:[126]:[32,22.22.22.22]
      22.22.22.22      0      100      32768      i  -----      MPLS
* i  [3]:[126]:[32,29.29.29.29]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS

RD[22.22.22.22:200] VRF[blue]:
*>  [2]:[0]:[200]:[48,e49d:73b3:c101]:[32,70.70.1.1]:[25636]
      22.22.22.22      0      100      32768      i  -----      MPLS
*>  [3]:[200]:[32,22.22.22.22]
      22.22.22.22      0      100      32768      i  -----      MPLS

RD[22.22.22.22:205] VRF[vrf205_mgmt]:
*>  [2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]
      22.22.22.22      0      100      32768      i  -----      MPLS
*>  [2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]
      22.22.22.22      0      100      32768      i  -----      MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[22]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[22]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[22]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[22]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1]:[22]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1]:[22]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
      10.10.10.10      0      100      0      i  10.10.10.10      MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
      10.10.10.10      0      100      0      i  10.10.10.10      MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1]:[26]
      10.10.10.10      0      100      0      i  10.10.10.10      MPLS
*>  [2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]
      22.22.22.22      0      100      32768      i  -----      MPLS
* i  [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS
* i  [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS
* i  [2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1]:[22]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS
* i  [3]:[127]:[32,10.10.10.10]
      10.10.10.10      0      100      0      i  10.10.10.10      MPLS
*>  [3]:[127]:[32,22.22.22.22]
      22.22.22.22      0      100      32768      i  -----      MPLS
* i  [3]:[127]:[32,29.29.29.29]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS

RD[22.22.22.22:500] VRF[ELAN_vrf500]:
* i  [3]:[500]:[32,10.10.10.10]
      10.10.10.10      0      100      0      i  10.10.10.10      MPLS
*>  [3]:[500]:[32,22.22.22.22]
      22.22.22.22      0      100      32768      i  -----      MPLS
* i  [3]:[500]:[32,29.29.29.29]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS

RD[22.22.22.22:501] VRF[ELAN_vrf501]:
*>  [3]:[501]:[32,22.22.22.22]
      22.22.22.22      0      100      32768      i  -----      MPLS
* i  [3]:[501]:[32,29.29.29.29]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS

RD[22.22.22.22:502] VRF[ELAN_vrf502]:
*>  [3]:[502]:[32,22.22.22.22]
      22.22.22.22      0      100      32768      i  -----      MPLS
* i  [3]:[502]:[32,29.29.29.29]
      29.29.29.29      0      100      0      i  29.29.29.29      MPLS

RD[22.22.22.22:503] VRF[ELAN_vrf503]:
*>  [3]:[503]:[32,22.22.22.22]

```

```

22.22.22.22      0      100      32768 i ----- MPLS
* i  [3]:[503]:[32,29.29.29.29]
29.29.29.29      0      100      0 i 29.29.29.29 MPLS

RD[22.22.22.22:504] VRF[ELAN_vrf504]:
*> [3]:[504]:[32,22.22.22.22]
22.22.22.22      0      100      32768 i ----- MPLS
* i  [3]:[504]:[32,29.29.29.29]
29.29.29.29      0      100      0 i 29.29.29.29 MPLS

RD[22.22.22.22:505] VRF[ELAN_vrf505]:
*> [3]:[505]:[32,22.22.22.22]
22.22.22.22      0      100      32768 i ----- MPLS
* i  [3]:[505]:[32,29.29.29.29]
29.29.29.29      0      100      0 i 29.29.29.29 MPLS

RD[22.22.22.22:506] VRF[ELAN_vrf506]:
*> [3]:[506]:[32,22.22.22.22]
22.22.22.22      0      100      32768 i ----- MPLS
* i  [3]:[506]:[32,29.29.29.29]
29.29.29.29      0      100      0 i 29.29.29.29 MPLS

RD[22.22.22.22:507] VRF[ELAN_vrf507]:
*> [3]:[507]:[32,22.22.22.22]
22.22.22.22      0      100      32768 i ----- MPLS
* i  [3]:[507]:[32,29.29.29.29]
29.29.29.29      0      100      0 i 29.29.29.29 MPLS

RD[22.22.22.22:508] VRF[ELAN_vrf508]:
*> [3]:[508]:[32,22.22.22.22]
22.22.22.22      0      100      32768 i ----- MPLS
* i  [3]:[508]:[32,29.29.29.29]
29.29.29.29      0      100      0 i 29.29.29.29 MPLS

RD[22.22.22.22:509] VRF[ELAN_vrf509]:
*> [3]:[509]:[32,22.22.22.22]
22.22.22.22      0      100      32768 i ----- MPLS
* i  [3]:[509]:[32,29.29.29.29]
29.29.29.29      0      100      0 i 29.29.29.29 MPLS

RD[22.22.22.22:510] VRF[ELAN_vrf510]:
*> [3]:[510]:[32,22.22.22.22]
22.22.22.22      0      100      32768 i ----- MPLS
* i  [3]:[510]:[32,29.29.29.29]
29.29.29.29      0      100      0 i 29.29.29.29 MPLS

RD[22.22.22.22:600] VRF[eline600]:
*> [1]:[0]:[600]:[25628]
22.22.22.22      0      100      32768 i ----- MPLS

RD[22.22.22.22:602] VRF[eline602]:
*> [1]:[0]:[602]:[25635]
22.22.22.22      0      100      32768 i ----- MPLS

RD[22.22.22.22:604] VRF[eline604]:
*> [1]:[0]:[604]:[25631]
22.22.22.22      0      100      32768 i ----- MPLS

RD[22.22.22.22:606] VRF[eline606]:
*> [1]:[0]:[606]:[25634]
22.22.22.22      0      100      32768 i ----- MPLS

RD[22.22.22.22:608] VRF[eline608]:
*> [1]:[0]:[608]:[25613]
22.22.22.22      0      100      32768 i ----- MPLS

RD[22.22.22.22:610] VRF[eline610]:
*> [1]:[0]:[610]:[25626]
22.22.22.22      0      100      32768 i ----- MPLS

RD[22.22.22.22:612] VRF[eline612]:
*> [1]:[0]:[612]:[25632]
22.22.22.22      0      100      32768 i ----- MPLS

```

```
RD[22.22.22.22:614] VRF[eline614]:
*> [1]:[0]:[614]:[25625]
      22.22.22.22      0      100      32768 i ----- MPLS

RD[22.22.22.22:616] VRF[eline616]:
*> [1]:[0]:[616]:[25612]
      22.22.22.22      0      100      32768 i ----- MPLS

RD[22.22.22.22:618] VRF[eline618]:
*> [1]:[0]:[618]:[25617]
      22.22.22.22      0      100      32768 i ----- MPLS

RD[22.22.22.22:620] VRF[eline620]:
*> [1]:[0]:[620]:[25638]
      22.22.22.22      0      100      32768 i ----- MPLS

RD[22.22.22.22:2002] VRF[vrf2002]:
*> [1]:[0]:[2224]:[25630]
      22.22.22.22      0      100      32768 i ----- MPLS

RD[22.22.22.22:2003] VRF[vrf2003]:
*> [1]:[0]:[2226]:[25637]
      22.22.22.22      0      100      32768 i ----- MPLS

RD[22.22.22.22:2004] VRF[vrf2004]:
*> [1]:[0]:[2228]:[25633]
      22.22.22.22      0      100      32768 i ----- MPLS

RD[22.22.22.22:2005] VRF[vrf2005]:
*> [1]:[0]:[2300]:[25639]
      22.22.22.22      0      100      32768 i ----- MPLS

RD[29.29.29.29:123]
*>i [2]:[0]:[123]:[48,0011:2233:4567]:[32,99.99.99.1]:[28]
      29.29.29.29      0      100      0      i 29.29.29.29 MPLS
*>i [3]:[123]:[32,29.29.29.29]
      29.29.29.29      0      100      0      i 29.29.29.29 MPLS

RD[29.29.29.29:124]
*>i [2]:[0]:[124]:[48,0011:2233:4567]:[32,99.99.100.1]:[29]
      29.29.29.29      0      100      0      i 29.29.29.29 MPLS
*>i [3]:[124]:[32,29.29.29.29]
      29.29.29.29      0      100      0      i 29.29.29.29 MPLS

RD[29.29.29.29:125]
*>i [2]:[0]:[125]:[48,0011:2233:4567]:[32,88.88.3.1]:[37]
      29.29.29.29      0      100      0      i 29.29.29.29 MPLS
*>i [3]:[125]:[32,29.29.29.29]
      29.29.29.29      0      100      0      i 29.29.29.29 MPLS

RD[29.29.29.29:126]
*>i [3]:[126]:[32,29.29.29.29]
      29.29.29.29      0      100      0      i 29.29.29.29 MPLS

RD[29.29.29.29:205]
*>i [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[22]
      29.29.29.29      0      100      0      i 29.29.29.29 MPLS
*>i [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[22]
      29.29.29.29      0      100      0      i 29.29.29.29 MPLS
*>i [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1]:[22]
      29.29.29.29      0      100      0      i 29.29.29.29 MPLS
*>i [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]
      29.29.29.29      0      100      0      i 29.29.29.29 MPLS
*>i [2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1]:[22]
      29.29.29.29      0      100      0      i 29.29.29.29 MPLS
*>i [3]:[127]:[32,29.29.29.29]
      29.29.29.29      0      100      0      i 29.29.29.29 MPLS

RD[29.29.29.29:305]
*>i [5]:[0]:[0]:[24]:[99.99.101.0]:[0.0.0.0]:[18]
      29.29.29.29      0      100      0      ? 29.29.29.29 MPLS
*>i [5]:[0]:[0]:[24]:[103.103.103.0]:[0.0.0.0]:[18]
```

```

                29.29.29.29          0          100          0    ?  29.29.29.29    MPLS
*>i  [5]:[0]:[0]:[24]:[104.104.104.0]:[0.0.0.0]:[18]
                29.29.29.29          0          100          0    ?  29.29.29.29    MPLS

RD[29.29.29.29:333]
*>i  [5]:[0]:[0]:[24]:[99.99.99.0]:[0.0.0.0]:[20]
                29.29.29.29          0          100          0    ?  29.29.29.29    MPLS

RD[29.29.29.29:334]
*>i  [5]:[0]:[0]:[24]:[99.99.100.0]:[0.0.0.0]:[19]
                29.29.29.29          0          100          0    ?  29.29.29.29    MPLS

RD[29.29.29.29:500]
*>i  [3]:[500]:[32,29.29.29.29]
                29.29.29.29          0          100          0    i  29.29.29.29    MPLS

RD[29.29.29.29:501]
*>i  [3]:[501]:[32,29.29.29.29]
                29.29.29.29          0          100          0    i  29.29.29.29    MPLS

RD[29.29.29.29:502]
*>i  [3]:[502]:[32,29.29.29.29]
                29.29.29.29          0          100          0    i  29.29.29.29    MPLS

RD[29.29.29.29:503]
*>i  [3]:[503]:[32,29.29.29.29]
                29.29.29.29          0          100          0    i  29.29.29.29    MPLS

RD[29.29.29.29:504]
*>i  [3]:[504]:[32,29.29.29.29]
                29.29.29.29          0          100          0    i  29.29.29.29    MPLS

RD[29.29.29.29:505]
*>i  [3]:[505]:[32,29.29.29.29]
                29.29.29.29          0          100          0    i  29.29.29.29    MPLS

RD[29.29.29.29:506]
*>i  [3]:[506]:[32,29.29.29.29]
                29.29.29.29          0          100          0    i  29.29.29.29    MPLS

RD[29.29.29.29:507]
*>i  [3]:[507]:[32,29.29.29.29]
                29.29.29.29          0          100          0    i  29.29.29.29    MPLS

RD[29.29.29.29:508]
*>i  [3]:[508]:[32,29.29.29.29]
                29.29.29.29          0          100          0    i  29.29.29.29    MPLS

RD[29.29.29.29:509]
*>i  [3]:[509]:[32,29.29.29.29]
                29.29.29.29          0          100          0    i  29.29.29.29    MPLS

RD[29.29.29.29:510]
*>i  [3]:[510]:[32,29.29.29.29]
                29.29.29.29          0          100          0    i  29.29.29.29    MPLS
```

Total number of prefixes 121

PE2 Verification:

```
#show bgp l2vpn evpn
BGP table version is 3, local router ID is 29.29.29.29
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
                l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]
```

- 1 - Ethernet Auto-discovery Route
- 2 - MAC/IP Route
- 3 - Inclusive Multicast Route
- 4 - Ethernet Segment Route
- 5 - Prefix Route

Network	Next Hop	Metric	LocPrf	Weight	Path	Peer	Encap
RD[20:200]							
*>i [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]	10.10.10.10	0	100	0	?	10.10.10.10	MPLS
RD[30:200]							
*>i [5]:[0]:[0]:[24]:[70.70.1.0]:[0.0.0.0]:[25600]	22.22.22.22	0	100	0	?	22.22.22.22	MPLS
RD[10.10.10.10:123]							
*>i [2]:[0]:[123]:[48,0011:2233:4567]:[32,99.99.99.1]:[22]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>i [3]:[123]:[32,10.10.10.10]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
RD[10.10.10.10:124]							
*>i [2]:[0]:[124]:[48,0011:2233:4567]:[32,99.99.100.1]:[24]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>i [3]:[124]:[32,10.10.10.10]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
RD[10.10.10.10:125]							
*>i [2]:[0]:[125]:[48,0011:2233:4567]:[32,88.88.3.1]:[21]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>i [3]:[125]:[32,10.10.10.10]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
RD[10.10.10.10:126]							
*>i [3]:[126]:[32,10.10.10.10]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
RD[10.10.10.10:200]							
*>i [2]:[0]:[100]:[48,d077:ce2a:8001]:[32,80.80.1.1]:[23]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>i [3]:[100]:[32,10.10.10.10]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
RD[10.10.10.10:205]							
*>i [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[26]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>i [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>i [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1]:[26]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>i [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>i [2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1]:[26]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>i [3]:[127]:[32,10.10.10.10]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
RD[10.10.10.10:305]							
*>i [5]:[0]:[0]:[24]:[99.99.101.0]:[0.0.0.0]:[17]	10.10.10.10	0	100	0	?	10.10.10.10	MPLS
*>i [5]:[0]:[0]:[24]:[103.103.103.0]:[0.0.0.0]:[17]	10.10.10.10	0	100	0	?	10.10.10.10	MPLS
*>i [5]:[0]:[0]:[24]:[104.104.104.0]:[0.0.0.0]:[17]	10.10.10.10	0	100	0	?	10.10.10.10	MPLS
RD[10.10.10.10:333]							
*>i [5]:[0]:[0]:[24]:[99.99.99.0]:[0.0.0.0]:[19]	10.10.10.10	0	100	0	?	10.10.10.10	MPLS

```
RD[10.10.10.10:334]
*>i  [5]:[0]:[0]:[24]:[99.99.100.0]:[0.0.0.0]:[18]
      10.10.10.10      0      100      0      ?  10.10.10.10      MPLS

RD[10.10.10.10:500]
*>i  [3]:[500]:[32,10.10.10.10]
      10.10.10.10      0      100      0      i  10.10.10.10      MPLS

RD[22.22.22.22:123]
*>i  [2]:[0]:[123]:[48,0011:2233:4455]:[32,98.98.98.1]:[25618]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS
*>i  [3]:[123]:[32,22.22.22.22]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS

RD[22.22.22.22:124]
*>i  [2]:[0]:[124]:[48,0011:2233:4455]:[32,98.98.99.1]:[25619]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS
*>i  [3]:[124]:[32,22.22.22.22]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS

RD[22.22.22.22:125]
*>i  [2]:[0]:[125]:[48,0011:2233:4455]:[32,88.88.1.1]:[25629]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS
*>i  [3]:[125]:[32,22.22.22.22]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS

RD[22.22.22.22:126]
*>i  [3]:[126]:[32,22.22.22.22]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS

RD[22.22.22.22:205]
*>i  [2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS
*>i  [2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS
*>i  [2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS
*>i  [3]:[127]:[32,22.22.22.22]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS

RD[22.22.22.22:305]
*>i  [5]:[0]:[0]:[24]:[98.98.101.0]:[0.0.0.0]:[25601]
      22.22.22.22      0      100      0      ?  22.22.22.22      MPLS
*>i  [5]:[0]:[0]:[24]:[103.103.102.0]:[0.0.0.0]:[25601]
      22.22.22.22      0      100      0      ?  22.22.22.22      MPLS
*>i  [5]:[0]:[0]:[24]:[104.104.103.0]:[0.0.0.0]:[25601]
      22.22.22.22      0      100      0      ?  22.22.22.22      MPLS

RD[22.22.22.22:333]
*>i  [5]:[0]:[0]:[24]:[98.98.98.0]:[0.0.0.0]:[25606]
      22.22.22.22      0      100      0      ?  22.22.22.22      MPLS

RD[22.22.22.22:334]
*>i  [5]:[0]:[0]:[24]:[98.98.99.0]:[0.0.0.0]:[25605]
      22.22.22.22      0      100      0      ?  22.22.22.22      MPLS

RD[22.22.22.22:335]
*>i  [5]:[0]:[0]:[24]:[88.88.1.0]:[0.0.0.0]:[25604]
      22.22.22.22      0      100      0      ?  22.22.22.22      MPLS

RD[22.22.22.22:500]
*>i  [3]:[500]:[32,22.22.22.22]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS

RD[22.22.22.22:501]
*>i  [3]:[501]:[32,22.22.22.22]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS

RD[22.22.22.22:502]
*>i  [3]:[502]:[32,22.22.22.22]
      22.22.22.22      0      100      0      i  22.22.22.22      MPLS

RD[22.22.22.22:503]
```

```

*>i  [3]:[503]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS

RD[22.22.22.22:504]
*>i  [3]:[504]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS

RD[22.22.22.22:505]
*>i  [3]:[505]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS

RD[22.22.22.22:506]
*>i  [3]:[506]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS

RD[22.22.22.22:507]
*>i  [3]:[507]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS

RD[22.22.22.22:508]
*>i  [3]:[508]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS

RD[22.22.22.22:509]
*>i  [3]:[509]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS

RD[22.22.22.22:510]
*>i  [3]:[510]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS

RD[29.29.29.29:123] VRF[vrf100_mgmt]:
* i  [2]:[0]:[123]:[48,0011:2233:4455]:[32,98.98.98.1]:[25618]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
* i  [2]:[0]:[123]:[48,0011:2233:4567]:[32,99.99.99.1]:[22]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
*>
      29.29.29.29          0          100          32768 i  -----    MPLS
* i  [3]:[123]:[32,10.10.10.10]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
* i  [3]:[123]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
*>
      [3]:[123]:[32,29.29.29.29]
      29.29.29.29          0          100          32768 i  -----    MPLS

RD[29.29.29.29:124] VRF[vrf200_mgmt]:
* i  [2]:[0]:[124]:[48,0011:2233:4455]:[32,98.98.99.1]:[25619]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
* i  [2]:[0]:[124]:[48,0011:2233:4567]:[32,99.99.100.1]:[24]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
*>
      29.29.29.29          0          100          32768 i  -----    MPLS
* i  [3]:[124]:[32,10.10.10.10]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
* i  [3]:[124]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
*>
      [3]:[124]:[32,29.29.29.29]
      29.29.29.29          0          100          32768 i  -----    MPLS

RD[29.29.29.29:125] VRF[vrf201_mgmt]:
* i  [2]:[0]:[125]:[48,0011:2233:4455]:[32,88.88.1.1]:[25629]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
* i  [2]:[0]:[125]:[48,0011:2233:4567]:[32,88.88.3.1]:[21]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
*>
      29.29.29.29          0          100          32768 i  -----    MPLS
* i  [3]:[125]:[32,10.10.10.10]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
* i  [3]:[125]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
*>
      [3]:[125]:[32,29.29.29.29]
      29.29.29.29          0          100          32768 i  -----    MPLS

RD[29.29.29.29:126] VRF[vrf202_mgmt]:
* i  [3]:[126]:[32,10.10.10.10]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS

```



```

* i  [3]:[126]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
*>   [3]:[126]:[32,29.29.29.29]
      29.29.29.29          0          100          32768 i  ----- MPLS

RD[29.29.29.29:200] VRF[blue]:
* i  [2]:[0]:[100]:[48,d077:ce2a:8001]:[32,80.80.1.1]:[23]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
*>   [2]:[0]:[100]:[48,e8c5:7aff:96de]:[32,80.80.1.1]:[38]
      29.29.29.29          0          100          32768 i  ----- MPLS
* i  [3]:[100]:[32,10.10.10.10]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
*>   [3]:[100]:[32,29.29.29.29]
      29.29.29.29          0          100          32768 i  ----- MPLS

RD[29.29.29.29:205] VRF[vrf205_mgmt]:
* i  [2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[26]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
*>   [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[26]
      29.29.29.29          0          100          32768 i  ----- MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
*>   [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]
      29.29.29.29          0          100          32768 i  ----- MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1]:[26]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
*>   [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1]:[26]
      29.29.29.29          0          100          32768 i  ----- MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1]:[26]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
* i  [2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
*>   [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]
      29.29.29.29          0          100          32768 i  ----- MPLS
*>   [2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1]:[22]
      29.29.29.29          0          100          32768 i  ----- MPLS
* i  [3]:[127]:[32,10.10.10.10]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
* i  [3]:[127]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
*>   [3]:[127]:[32,29.29.29.29]
      29.29.29.29          0          100          32768 i  ----- MPLS

RD[29.29.29.29:500] VRF[ELAN_vrf500]:
* i  [3]:[500]:[32,10.10.10.10]
      10.10.10.10          0          100          0    i  10.10.10.10    MPLS
* i  [3]:[500]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
*>   [3]:[500]:[32,29.29.29.29]
      29.29.29.29          0          100          32768 i  ----- MPLS

RD[29.29.29.29:501] VRF[ELAN_vrf501]:
* i  [3]:[501]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
*>   [3]:[501]:[32,29.29.29.29]
      29.29.29.29          0          100          32768 i  ----- MPLS

RD[29.29.29.29:502] VRF[ELAN_vrf502]:
* i  [3]:[502]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
*>   [3]:[502]:[32,29.29.29.29]
      29.29.29.29          0          100          32768 i  ----- MPLS

RD[29.29.29.29:503] VRF[ELAN_vrf503]:
* i  [3]:[503]:[32,22.22.22.22]
      22.22.22.22          0          100          0    i  22.22.22.22    MPLS
*>   [3]:[503]:[32,29.29.29.29]
      29.29.29.29          0          100          32768 i  ----- MPLS

RD[29.29.29.29:504] VRF[ELAN_vrf504]:

```

```

* i  [3]:[504]:[32,22.22.22.22]
      22.22.22.22          0      100      0      i  22.22.22.22      MPLS
*>   [3]:[504]:[32,29.29.29.29]
      29.29.29.29          0      100      32768  i  -----      MPLS

RD[29.29.29.29:505] VRF[ELAN_vrf505]:
* i  [3]:[505]:[32,22.22.22.22]
      22.22.22.22          0      100      0      i  22.22.22.22      MPLS
*>   [3]:[505]:[32,29.29.29.29]
      29.29.29.29          0      100      32768  i  -----      MPLS

RD[29.29.29.29:506] VRF[ELAN_vrf506]:
* i  [3]:[506]:[32,22.22.22.22]
      22.22.22.22          0      100      0      i  22.22.22.22      MPLS
*>   [3]:[506]:[32,29.29.29.29]
      29.29.29.29          0      100      32768  i  -----      MPLS

RD[29.29.29.29:507] VRF[ELAN_vrf507]:
* i  [3]:[507]:[32,22.22.22.22]
      22.22.22.22          0      100      0      i  22.22.22.22      MPLS
*>   [3]:[507]:[32,29.29.29.29]
      29.29.29.29          0      100      32768  i  -----      MPLS

RD[29.29.29.29:508] VRF[ELAN_vrf508]:
* i  [3]:[508]:[32,22.22.22.22]
      22.22.22.22          0      100      0      i  22.22.22.22      MPLS
*>   [3]:[508]:[32,29.29.29.29]
      29.29.29.29          0      100      32768  i  -----      MPLS

RD[29.29.29.29:509] VRF[ELAN_vrf509]:
* i  [3]:[509]:[32,22.22.22.22]
      22.22.22.22          0      100      0      i  22.22.22.22      MPLS
*>   [3]:[509]:[32,29.29.29.29]
      29.29.29.29          0      100      32768  i  -----      MPLS

RD[29.29.29.29:510] VRF[ELAN_vrf510]:
* i  [3]:[510]:[32,22.22.22.22]
      22.22.22.22          0      100      0      i  22.22.22.22      MPLS
*>   [3]:[510]:[32,29.29.29.29]
      29.29.29.29          0      100      32768  i  -----      MPLS

RD[29.29.29.29:650] VRF[vrf650]:
*>   [3]:[650]:[32,29.29.29.29]
      29.29.29.29          0      100      32768  i  -----      MPLS

```

Total number of prefixes 110

Verify the specific type of EVPN routes using VRF:

PE1:

```
#show bgp l2vpn evpn vrf vrf205_mgmt
```

BGP table version is 1, local router ID is 22.22.22.22

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

```
[EVPN route type]:[ESI]:[VNID]:[relevant route information]
```

1 - Ethernet Auto-discovery Route

2 - MAC/IP Route

3 - Inclusive Multicast Route

4 - Ethernet Segment Route

5 - Prefix Route

```

Network          Next Hop          Metric    LocPrf    Weight    Path Peer          Encap
*> [2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]
    22.22.22.22          0          100      32768    i  -----          MPLS
*> [2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]
    22.22.22.22          0          100      32768    i  -----          MPLS
* i [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[22]
    29.29.29.29          0          100          0    i  29.29.29.29          MPLS
* i [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[22]
    29.29.29.29          0          100          0    i  29.29.29.29          MPLS
* i [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[22]
    10.10.10.10          0          100          0    i  10.10.10.10          MPLS
* i [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[22]
    29.29.29.29          0          100          0    i  29.29.29.29          MPLS
* i [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[22]
    10.10.10.10          0          100          0    i  10.10.10.10          MPLS
* i [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1][22]
    29.29.29.29          0          100          0    i  29.29.29.29          MPLS
* i [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1][22]
    10.10.10.10          0          100          0    i  10.10.10.10          MPLS
* i [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
    10.10.10.10          0          100          0    i  10.10.10.10          MPLS
* i [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
    10.10.10.10          0          100          0    i  10.10.10.10          MPLS
*> [2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]
    22.22.22.22          0          100      32768    i  -----          MPLS
* i [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]
    29.29.29.29          0          100          0    i  29.29.29.29          MPLS
* i [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]
    29.29.29.29          0          100          0    i  29.29.29.29          MPLS
* i [2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1][22]
    29.29.29.29          0          100          0    i  29.29.29.29          MPLS
* i [3]:[127]:[32,10.10.10.10]
    10.10.10.10          0          100          0    i  10.10.10.10          MPLS
*> [3]:[127]:[32,22.22.22.22]
    22.22.22.22          0          100      32768    i  -----          MPLS
* i [3]:[127]:[32,29.29.29.29]
    29.29.29.29          0          100          0    i  29.29.29.29          MPLS

```

Total number of prefixes 13

PE2:

```
#show bgp l2vpn evpn vrf vrf205_mgmt
```

BGP table version is 1, local router ID is 29.29.29.29

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

```
[EVPN route type]:[ESI]:[VNID]:[relevant route information]
```

1 - Ethernet Auto-discovery Route

2 - MAC/IP Route

3 - Inclusive Multicast Route

4 - Ethernet Segment Route

5 - Prefix Route

```

Network          Next Hop          Metric    LocPrf    Weight    Path Peer          Encap
* i [2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]
    22.22.22.22          0          100          0    i  22.22.22.22          MPLS
* i [2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]
    22.22.22.22          0          100          0    i  22.22.22.22          MPLS
* i [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[26]
    10.10.10.10          0          100          0    i  10.10.10.10          MPLS
*> [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[26]
    29.29.29.29          0          100      32768    i  -----          MPLS
* i [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]
    10.10.10.10          0          100          0    i  10.10.10.10          MPLS
*> [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]
    29.29.29.29          0          100      32768    i  -----          MPLS
* i [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1][26]
    10.10.10.10          0          100          0    i  10.10.10.10          MPLS
*> [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1][26]
    29.29.29.29          0          100      32768    i  -----          MPLS
* i [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
    10.10.10.10          0          100          0    i  10.10.10.10          MPLS

```

* i	[2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1]	[26] 10.10.10.10 0 100 0	i	10.10.10.10	MPLS
* i	[2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]	22.22.22.22 0 100 0	i	22.22.22.22	MPLS
>	[2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]	29.29.29.29 0 100			
>	[2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1]	[22] 29.29.29.29 0 100			
* i	[3]:[127]:[32,10.10.10.10]	10.10.10.10 0 100	i	10.10.10.10	MPLS
* i	[3]:[127]:[32,22.22.22.22]	22.22.22.22 0 100	i	22.22.22.22	MPLS
>	[3]:[127]:[32,29.29.29.29]	29.29.29.29 0 100			

Total number of prefixes 13

Verify the specific type of EVPN routes using RD:

PE1:

```
#show bgp l2vpn evpn rd 22.22.22.22:205
```

```
BGP table version is 2, local router ID is 22.22.22.22
```

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

1 - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

```
[EVPN route type]:[ESI]:[VNID]:[relevant route information]
```

- 1 - Ethernet Auto-discovery Route
- 2 - MAC/IP Route
- 3 - Inclusive Multicast Route
- 4 - Ethernet Segment Route
- 5 - Prefix Route

Network	Next Hop	Metric	LocPrf	Weight	Path	Peer	Encap
RD[22.22.22.22:205] VRF[vrf205_mgmt]:							
*>	[2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]						
	22.22.22.22	0	100	32768	i	-----	MPLS
*>	[2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]						
	22.22.22.22	0	100	32768	i	-----	MPLS
* i	[2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[22]						
	29.29.29.29	0	100	0	i	29.29.29.29	MPLS
* i	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
* i	[2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[22]						
	29.29.29.29	0	100	0	i	29.29.29.29	MPLS
* i	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
* i	[2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1]:[22]						
	29.29.29.29	0	100	0	i	29.29.29.29	MPLS
* i	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
* i	[2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]						
	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
* i	[2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1]:[26]						
	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>	[2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]						
	22.22.22.22	0	100	32768	i	-----	MPLS
* i	[2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]						
	29.29.29.29	0	100	0	i	29.29.29.29	MPLS
* i	[2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1]:[22]						
	29.29.29.29	0	100	0	i	29.29.29.29	MPLS
* i	[3]:[127]:[32,10.10.10.10]						
	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*>	[3]:[127]:[32,22.22.22.22]						
	22.22.22.22	0	100	32768	i	-----	MPLS
* i	[3]:[127]:[32,29.29.29.29]						

Network	Next Hop	Metric	LocPrf	Weight	Path	Peer	Encap
29.29.29.29	0	100	0	i	29.29.29.29	MPLS	

Total number of prefixes 13

PE2:

```
#show bgp l2vpn evpn rd 29.29.29.29:205
```

BGP table version is 3, local router ID is 29.29.29.29

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]

1 - Ethernet Auto-discovery Route

2 - MAC/IP Route

3 - Inclusive Multicast Route

4 - Ethernet Segment Route

5 - Prefix Route

Network	Next Hop	Metric	LocPrf	Weight	Path	Peer	Encap
RD[29.29.29.29:205] VRF[vrf205_mgmt]:							
* i [2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]	22.22.22.22	0	100	0	i	22.22.22.22	MPLS
* i [2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]	22.22.22.22	0	100	0	i	22.22.22.22	MPLS
* i [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[26]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*> [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]	29.29.29.29	0	100	32768	i	-----	MPLS
* i [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*> [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]	29.29.29.29	0	100	32768	i	-----	MPLS
* i [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1]:[26]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
*> [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1]:[26]	29.29.29.29	0	100	32768	i	-----	MPLS
* i [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
* i [2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1]:[26]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
* i [2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]	22.22.22.22	0	100	0	i	22.22.22.22	MPLS
*> [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]	29.29.29.29	0	100	32768	i	-----	MPLS
*> [2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1]:[22]	29.29.29.29	0	100	32768	i	-----	MPLS
* i [3]:[127]:[32,10.10.10.10]	10.10.10.10	0	100	0	i	10.10.10.10	MPLS
* i [3]:[127]:[32,22.22.22.22]	22.22.22.22	0	100	0	i	22.22.22.22	MPLS
*> [3]:[127]:[32,29.29.29.29]	29.29.29.29	0	100	32768	i	-----	MPLS

Total number of prefixes 13

Verify the specific type of EVPN routes using Prefix:

PE1:

```
#show bgp l2vpn evpn prefix [3]:[127]:[32,29.29.29.29]
```

BGP table version is 2, local router ID is 22.22.22.22

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]

1 - Ethernet Auto-discovery Route

2 - MAC/IP Route

3 - Inclusive Multicast Route

4 - Ethernet Segment Route

5 - Prefix Route

Network	Next Hop	Metric	LocPrf	Weight	Path	Peer	Encap
RD[22.22.22.22:205] VRF[vrf205_mgmt]:							
* i [3]:[127]:[32,29.29.29.29]	29.29.29.29	0	100	0	i	29.29.29.29	MPLS
RD[29.29.29.29:205]							
*>i [3]:[127]:[32,29.29.29.29]	29.29.29.29	0	100	0	i	29.29.29.29	MPLS

Total number of prefixes 2

PE2:

#show bgp l2vpn evpn prefix [3]:[127]:[32,22.22.22.22]

BGP table version is 3, local router ID is 29.29.29.29

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]

1 - Ethernet Auto-discovery Route

2 - MAC/IP Route

3 - Inclusive Multicast Route

4 - Ethernet Segment Route

5 - Prefix Route

Network	Next Hop	Metric	LocPrf	Weight	Path	Peer	Encap
RD[22.22.22.22:205]							
*>i [3]:[127]:[32,22.22.22.22]	22.22.22.22	0	100	0	i	22.22.22.22	MPLS
RD[29.29.29.29:205] VRF[vrf205_mgmt]:							
* i [3]:[127]:[32,22.22.22.22]	22.22.22.22	0	100	0	i	22.22.22.22	MPLS

Total number of prefixes 2

Verify the specific type of EVPN routes using both VRF and Prefix:

PE1:

```
#show bgp l2vpn evpn vrf vrf205_mgmt prefix [3]:[127]:[32,29.29.29.29]
BGP table version is 1, local router ID is 22.22.22.22
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
                1 - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route
```

	Network	Next Hop	Metric	LocPrf	Weight	Path	Peer	Encap
* i	[3]:[127]:[32,29.29.29.29]	29.29.29.29	0	100	0	i	29.29.29.29	MPLS

Total number of prefixes 1

PE2:

```
#show bgp l2vpn evpn vrf vrf205_mgmt prefix [3]:[127]:[32,22.22.22.22]
BGP table version is 1, local router ID is 29.29.29.29
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
                1 - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route
```

	Network	Next Hop	Metric	LocPrf	Weight	Path	Peer	Encap
* i	[3]:[127]:[32,22.22.22.22]	22.22.22.22	0	100	0	i	22.22.22.22	MPLS

Total number of prefixes 1

Verify detailed information of EVPN routes:**PE1:**

```
#show bgp l2vpn evpn vrf vrf205_mgmt prefix [3]:[127]:[32,29.29.29.29] detail

BGP route entry for prefix : [3]:[127]:[32,29.29.29.29]
Route-Distinguisher: [29.29.29.29:205]
Flags : Valid, IBGP
Nexthop : 29.29.29.29 MED value : 0
Community:
```

```
Extended Community: RT:65535:1073741951  Encapsulation:MPLS
Weight :0,  Local Preference :100
AS Path : Local
Origin : IGP
Last Update : Mon Oct 9 10:14:47 2023
Peer : 29.29.29.29
```

Total number of prefixes 1

PE2:

```
#show bgp l2vpn evpn vrf vrf205_mgmt prefix [3]:[127]:[32,22.22.22.22] detail
```

```
BGP route entry for prefix : [3]:[127]:[32,22.22.22.22]
Route-Distinguisher: [22.22.22.22:205]
Flags : Valid, IBGP
Nexthop : 22.22.22.22  MED value : 0
Community:
Extended Community: RT:65535:1073741951  Encapsulation:MPLS
Weight :0,  Local Preference :100
AS Path : Local
Origin : IGP
Last Update : Mon Apr 15 07:05:47 2019
Peer : 22.22.22.22
```

Abbreviations

Acronym	Description
VNID	L2 Virtual Network Identifier
VRF	Virtual Routing and Forwarding
EVPN-IRB	Ethernet VPN Integrated Routing and Bridging
MAC	Media Access Control address

CHAPTER 10 CFM over EVPN-MPLS for ELINE MultiHoming

Overview

The Connectivity Fault Management (CFM) enhances the product offering for the Ethernet LINE (ELINE) services in MultiHoming scenarios. Based on the 802.1ag standard, CFM encompasses Continuity Check Message (CCM), Ping, and Trace functions that help in network fault detection and isolation. This feature extends CFM over EVPN-MPLS from being solely for Single-Homing deployments to a MultiHoming scenario, where a Remote Maintenance End Point (R-MEP) is treated as a single instance by MultiHoming peers.

The [Topology](#) illustrates the configuration of User-to-Provider (UP) MEP on PE2 and PE3 Access Circuit (AC) ports, along with the corresponding UP MEP configured on the remote AC port (PE1). This configuration results in the establishment of a CFM session between the PE VTEPs and the remote VTEP.

Feature Characteristics

Functional requirements for CFM over ELINE MultiHoming:

Continuity Check Message

Continuity Check Message (CCM) provides the following capabilities:

- Ensures error-free base configuration for EVPN-MPLS MultiHoming.
- Maintains uniformity of R-MEP and remote-MAC on MultiHoming nodes.
- Enables the data plane to notify the control plane of CCM timeout, port/interface state changes, and Remote Defect Indication (RDI).
- Configures the data plane to send and process CCMs at specified intervals, with options to enable/disable CCM transmission.
- Detects connectivity failures when no CCM frames are received within a set interval and notifies the control plane.
- Programs the data plane to include Port and Interface Status Type-Length-Values (TLVs) in transmitted CCM frames.
- Transmits CC Protocol Data Unit (PDU) frames with IEEE 802.1ag-2007 compliance and supports RDI bit set or reset operations.

Ping and Trace

Ping and Trace provide the following capabilities:

- Facilitates data plane snooping of LBM or Linktrace Message (LTM) received on MEP.
- Traps LTR PDUs received on MEP and processes/replies to LBM received on User-to-Provider (UP) MEP.
- Uplifts CFM PDUs from the data plane to the control plane, and sends CFM PDUs from the control plane to the data plane.
- Provides statistics counters for transmitted Loopback Replies (LBR) and encodes service frame counts in LBM and LBR PDUs.

Benefits

Enhanced Network Monitoring: CFM enables continuous monitoring of network connections, providing real-time insights into connectivity status and performance. This ensures that any issues are quickly detected and addressed.

Quick Fault Detection: Through CCM, the system promptly identifies any disruptions or faults in the network. This swift detection allows for rapid response and minimized downtime.

Efficient Troubleshooting: CFM's Ping and Trace functions help troubleshoot network problems by pinpointing the origin of issues and the paths taken by data packets. This capability streamlines the resolution process.

Robust MultiHoming Support: The extension of CFM support to MultiHoming scenarios ensures that complex network setups remain resilient and well-monitored, even in challenging environments.

Prerequisites

Before configuring and utilizing CFM for ELINE MultiHoming, ensure the following prerequisites are met:

- **Hardware Profiles Configuration**
 - Enable the required hardware profiles to facilitate CFM operations. These include `cfm-domain-name-str`, `cfm-ccm`, and `evpn-mpls-mh` profiles.
 - Establish the hardware-profile filter (`evpn-mpls-mh`) for EVPN-MPLS MultiHoming.
- **EVPN-MPLS Configuration**
 - Enable and configure EVPN MPLS on the relevant devices and enable MultiHoming support within EVPN MPLS.
- **ELINE Service Setup**
 - Establish the ELINE service and assign the corresponding VPN identifiers (VPN-ID).
 - Configure the host-reachability-protocol using EVPN BGP with the associated Virtual Routing and Forwarding (VRF).
- **ELINE AC MultiHoming Configuration**
 - Configure ELINE MultiHoming features with proper encapsulation settings (e.g., `dot1q`) and `access-if-evpn` settings on relevant interfaces.
 - Define the necessary mapping of VPN identifiers (VPN-ID) for the EVPN service.

For more information on the EVPN MPLS configurations, refer to the [EVPN MPLS Configuration](#) and [EVPN MPLS Commands](#) chapters in the *Multi-Protocol Label Switching Guide*.

- **MAC and MEP Considerations**
 - Ensure that the MEP on MultiHoming nodes has the same MAC. Consistent Media Access Control (MAC) addressing across Access Circuit (AC) ports is essential to facilitate single R-MEP consideration on MultiHoming peers.

For more information on the CFM configurations, refer to the Carrier Ethernet configuration section and [CFM and Y.1731 Commands](#) chapters in the *Carrier Ethernet Guide*.

Meeting these prerequisites ensures a successful setup of CFM for ELINE MultiHoming, enabling enhanced network fault detection and isolation capabilities.

Configuration

This section illustrates the MultiHomed setup for the CFM over EVPN MPLS feature, showcasing examples for ELINE services with LDP as the underlay MPLS path.

Topology

Figure 10-2 consists of customer edge routers CE1 and CE2, and with IPv4 Provider Edge routers PE1, PE2, and PE3, all interconnected through the core router P in the IPv4 MPLS provider network.

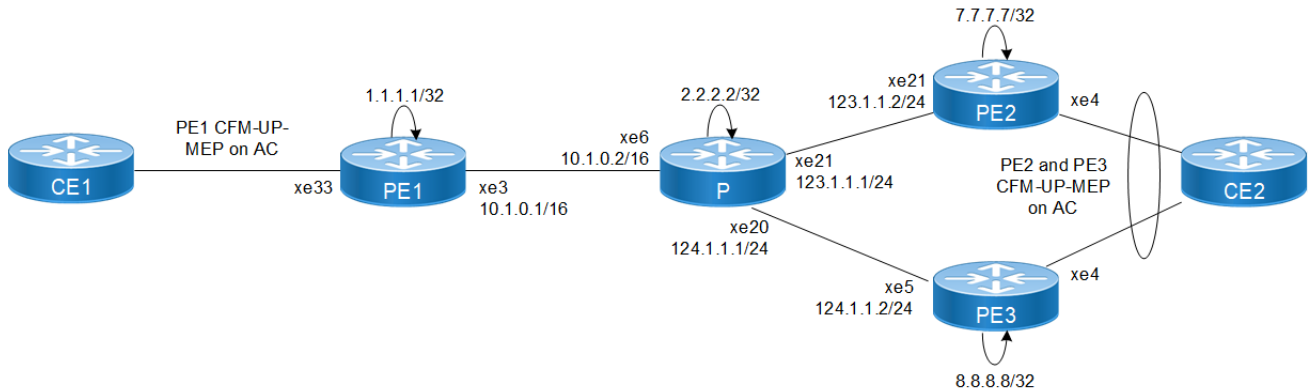


Figure 10-2: CFM over EVPN-MPLS for ELINE MH configuration

CFM Configuration

To enhance network management, monitoring, performance, and fault detection, configure the following hardware-profile commands on PE1, PE2, and PE3 devices, and here are the steps for the configurations: [PE1: CFM](#) and [PE2/PE3: CFM](#).

- Enable the filter for CFM domain name strings with the command `hardware-profile filter cfm-domain-name-str enable`. This filter enhances the network devices ability to process CFM domain name strings, facilitating better network management and service identification.
- Enable statistics collection for CFM Continuity Check Messages (CCM) using the command `hardware-profile statistics cfm-ccm enable`. This feature allows the network devices to gather valuable insights into network performance and fault detection by collecting and analyzing data related to CFM CCMs.

PE1: Loopback Interface

The configuration on PE1 for a loopback interface with IP address 1.1.1.1/32 secondary is set up to provide IP connectivity for the router.

PE1#configure terminal	Enter configure mode.
PE1(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE1(config-if)#ip address 1.1.1.1/32 secondary	Configure a secondary IP address, 1.1.1.1/32, on the loopback interface.
PE1(config-if)#exit	Exit interface mode lo.
PE1(config)#commit	Commit the transaction.

PE1: Global LDP

The configuration on PE1 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE1(config)#router ldp	Enter the Router LDP mode.
PE1(config-router)#router-id 1.1.1.1	Set the router ID for LDP to 1.1.1.1.
PE1(config-router)#targeted-peer ipv4 7.7.7.7	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE1(config-router)#targeted-peer ipv4 8.8.8.8	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE1(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: Global EVPN MPLS Command

The configuration on PE1 for the Global EVPN MPLS includes activating EVPN MPLS defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multihoming, and activating EVPN MPLS multihoming functionality, all of which are crucial for enabling EVPN MPLS features.

PE1(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE1, enabling it to participate in EVPN MPLS services.
PE1(config)#commit	Commit candidate configuration to be running configuration.
PE1(config)#evpn mpls vtep-ip-global 1.1.1.1	Configure the global VTEP IP address 1.1.1.1, associating it with the loopback IP.
PE1(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multihoming.
PE1(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multihoming functionality, allowing PE1 to support multihomed EVPN MPLS services.
PE1(config)#commit	Commit the transaction.

PE1: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE1 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE1(config)#interface xe3	Enter interface mode xe3.
PE1(config-if)#ip address 10.1.0.1/16	Configure an IP address, 10.1.0.1/16, on the interface xe3.
PE1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE1(config-if)#exit	Exit interface mode xe3.
PE1(config)#commit	Commit the transaction.

PE1: OSPF Configuration

The below configuration is performed to set up OSPF on PE1, specifying the router ID and defining network interfaces.

PE1(config)#router ospf 1	Enter the router OSPF mode. Configure PE1 to run OSPF with process ID 1.
PE1(config-router)#ospf router-id 1.1.1.1	Set the OSPF router ID to 1.1.1.1, identifying PE1 within the OSPF network.
PE1(config-router)#network 1.1.1.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
PE1(config-router)#network 10.1.0.0/16 area 0.0.0.0	Advertise network address in OSPF.
PE1(config-router)#exit	Exit router OSPF mode and return to configure mode.
PE1(config)#commit	Commit the transaction.

PE1: BGP Configuration

The below BGP configuration on PE1 is established to enable BGP routing with ASN 1, set the BGP router ID, define iBGP neighbors, and enable the EVPN address family for efficient routing in an EVPN environment.

PE1(config)#router bgp 1	Enter the Router BGP mode, ASN: 1
PE1(config-router)#bgp router-id 1.1.1.1	Configure BGP router ID 1.1.1.1, identifying PE1 within the BGP network.
PE1(config-router)#neighbor 7.7.7.7 remote-as 1	Configure neighbor 7.7.7.7 as an iBGP neighbor with their remote AS number 1.
PE1(config-router)#neighbor 7.7.7.7 update-source lo	Configure neighbor 7.7.7.7 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE1(config-router)#neighbor 8.8.8.8 remote-as 1	Configure neighbor 8.8.8.8 as an iBGP neighbor with their remote AS number 1.
PE1(config-router)#neighbor 8.8.8.8 update-source lo	Configure neighbor 8.8.8.8 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE1(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE1(config-router-af)#neighbor 7.7.7.7 activate	Activate EVPN for iBGP neighbor 7.7.7.7 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE1(config-router-af)#neighbor 8.8.8.8 activate	Activate EVPN for iBGP neighbor 8.8.8.8 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE1(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE1(config-router)#commit	Commit the transaction.
PE1(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE1: MAC VRF Configuration

The below MAC VRF configuration on PE1 is carried out to define and set up VRF named `vrf2` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE1(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE1(config-vrf)#rd 1.1.1.1:2	Configure Route-Distinguisher value of 1.1.1.1:2.
PE1(config-vrf)#route-target both 2:2	Configure import and export values for the vrf2 as 2:2.

PE1(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: EVPN and VRF Mapping

The EVPN and VRF mapping configuration on PE1 establishes mappings between the EVPN identifier and VRF, facilitating efficient routing and connectivity in an EVPN network environment.

PE1(config)#evpn mpls id 52 xconnect target-mpls-id 2	Configure the EVPN-VPWS identifier with a source identifier of 52 and a target identifier of 2.
PE1(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE1(config-evpn-mpls)#commit	Commit the transaction.
PE1(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration

The below access port configuration on PE1 is carried out to create a Layer 2 sub-interface within the physical interface, description the interface, configure the encapsulation with VLAN ID, and map VPN-ID for efficient network access and connectivity.

PE1(config)#interface xe33	Enter interface mode xe33.
PE1(config-if)#interface xe33.2 switchport	Create a Layer 2 sub-interface xe33.2 within the physical interface xe33.
PE1(config-if)#description access-side-int	Provide a description for the interface.
PE1(config-if)#encapsulation dot1q 2	Set encapsulation to dot1q with VLAN ID 2.
PE1(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE1(config-acc-if-evpn)#map vpn-id 52	Map VPN-ID 52.
PE1(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE1(config-if)#exit	Exit interface mode xe33 and return to the configure mode.
PE1(config)#commit	Commit the transaction.

P: Loopback Interface

The configuration on P for a loopback interface with IP address 2.2.2.2/32 secondary is set up to provide IP connectivity for the router.

P#configure terminal	Enter configure mode.
P(config)#interface lo	Enter the interface mode for the loopback interface lo.
P(config-if)#ip address 2.2.2.2/32 secondary	Configure a secondary IP address, 2.2.2.2/32, on the loopback interface.
P(config-if)#exit	Exit interface mode lo.
P(config)#commit	Commit the transaction.

P: Global LDP

The configuration on P for the Global LDP router, specifying router ID to set up Label Distribution Protocol (LDP) settings for MPLS.

P(config)#router ldp	Enter the Router LDP mode.
P(config-router)#router-id 2.2.2.2	Set the router ID for LDP to 2.2.2.2.
P(config-router)#exit	Exit router LDP mode and return to the configure mode.
P(config)#commit	Commit the transaction.

P: Interface Configuration

The below configuration is performed to set up interfaces on P and enable LDP for IPv4, ensuring proper routing and labeling functionality.

P(config)#interface xe6	Enter interface mode xe6.
P(config-if)#ip address 10.1.0.2/16	Configure an IP address, 10.1.0.2/16, on the interface xe6.
P(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P(config-if)#exit	Exit interface mode xe6.
P(config)#commit	Commit the transaction.
P(config)#interface xe21	Enter interface mode xe21.
P(config-if)#ip address 123.1.1.1/24	Configure an IP address, 123.1.1.1/24, on the interface xe21.
P(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P(config-if)#exit	Exit interface mode xe21.
P(config)#commit	Commit the transaction.
P(config)#interface xe20	Enter interface mode xe20.
P(config-if)#ip address 124.1.1.1/24	Configure an IP address, 124.1.1.1/24, on the interface xe20.
P(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P(config-if)#exit	Exit interface mode xe20.
P(config)#commit	Commit the transaction.

P: OSPF Configuration

The below configuration is performed to set up OSPF on P, specifying the router ID and defining network interfaces for efficient routing.

P(config)#router ospf 1	Enter the router OSPF mode. Configure P to run OSPF with process ID 1.
P(config-router)#ospf router-id 2.2.2.2	Set the OSPF router ID to 2.2.2.2, identifying P within the OSPF network.
P(config-router)#network 2.2.2.2/32 area 0.0.0.0	Advertise loopback address in OSPF.
P(config-router)#network 10.1.0.2/16 area 0.0.0.0	Advertise network address in OSPF.
P(config-router)#network 123.1.1.1/24 area 0.0.0.0	Advertise network address in OSPF.
P(config-router)#network 124.1.1.1/24 area 0.0.0.0	Advertise network address in OSPF.
P(config-router)#exit	Exit router OSPF mode and return to the configure mode.
P(config)#commit	Commit the transaction.

PE2: Loopback Interface

The configuration on PE2 for a loopback interface with IP address 7.7.7.7/32 secondary is set up to provide IP connectivity for the router.

PE2#configure terminal	Enter configure mode.
PE2(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE2(config-if)#ip address 7.7.7.7/32 secondary	Configure a secondary IP address, 7.7.7.7/32, on the loopback interface.
PE2(config-if)#exit	Exit interface mode lo.
PE2(config)#commit	Commit the transaction.

PE2: Global LDP

The configuration on PE2 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE2(config)#router ldp	Enter the Router LDP mode.
PE2(config-router)#router-id 7.7.7.7	Set the router ID for LDP to 7.7.7.7.
PE2(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer for LDP using IPv4 addresses.
PE2(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE2(config-router)#targeted-peer ipv4 8.8.8.8	Configure targeted peer for LDP using IPv4 addresses.
PE2(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE2(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE2: Global EVPN MPLS Command

The configuration on PE2 for the Global EVPN MPLS, includes activating EVPN MPLS defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multihoming, and activating EVPN MPLS multihoming functionality, all of which are crucial for enabling EVPN MPLS features.

PE2(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE2, enabling it to participate in EVPN MPLS services.
PE2(config)#commit	Commit candidate configuration to be running configuration.
PE2(config)#evpn mpls vtep-ip-global 7.7.7.7	Configure the global VTEP IP address 7.7.7.7, associating it with the loopback IP.
PE2(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multihoming.
PE2(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multihoming functionality, allowing PE2 to support multihomed EVPN MPLS services.
PE2(config)#commit	Commit the transaction.

PE2: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE2 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE2(config)#interface xe21	Enter interface mode xe21.
PE2(config-if)#ip address 123.1.1.2/24	Configure an IP address, 123.1.1.2/24, on the interface xe21.
PE2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE2(config-if)#exit	Exit interface mode xe21.
PE2(config)#commit	Commit the transaction.

PE2: OSPF Configuration

The below configuration is performed to set up OSPF on PE2, specifying the router ID and defining network interfaces.

PE2(config)#router ospf 1	Enter the router OSPF mode. Configure PE2 to run OSPF with process ID 1.
PE2(config-router)#ospf router-id 7.7.7.7	Set the OSPF router ID to 7.7.7.7, identifying PE2 within the OSPF network.
PE2(config-router)#network 7.7.7.7/32 area 0.0.0.0	Advertise loopback address in OSPF.
PE2(config-router)#network 123.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
PE2(config-router)#exit	Exit router OSPF mode and return to configure mode.
PE2(config)#commit	Commit the transaction.

PE2: BGP Configuration

The below BGP configuration on PE2 is established to enable BGP routing with ASN 1, set the BGP router ID, define iBGP neighbors, and enable the EVPN address family for efficient routing in an EVPN environment.

PE2(config)#router bgp 1	Enter the Router BGP mode, ASN: 1
PE2(config-router)#bgp router-id 7.7.7.7	Configure BGP router ID 7.7.7.7, identifying PE2 within the BGP network.
PE2(config-router)#neighbor 1.1.1.1 remote-as 1	Configure neighbor 1.1.1.1 as an iBGP neighbor with their remote AS number 1.
PE2(config-router)#neighbor 1.1.1.1 update-source lo	Configure neighbor 1.1.1.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE2(config-router)#neighbor 8.8.8.8 remote-as 1	Configure neighbor 8.8.8.8 as an iBGP neighbor with their remote AS number 1.
PE2(config-router)#neighbor 8.8.8.8 update-source lo	Configure neighbor 8.8.8.8 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE2(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE2(config-router-af)#neighbor 1.1.1.1 activate	Activate EVPN for iBGP neighbor 1.1.1.1 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE2(config-router-af)#neighbor 8.8.8.8 activate	Activate EVPN for iBGP neighbor 8.8.8.8 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE2(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE2(config-router)#commit	Commit the transaction.
PE2(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE2: MAC VRF Configuration

The below MAC VRF configuration on PE2 is carried out to define and set up VRF named `vrf2` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE2(config)#mac vrf vrf2	Enter VRF mode named <code>vrf2</code> .
PE2(config-vrf)#rd 7.7.7.7:2	Configure Route-Distinguisher value of 7.7.7.7:2.
PE2(config-vrf)#route-target both 2:2	Configure import and export values for the <code>vrf2</code> as 2:2.
PE2(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE2: EVPN and VRF Mapping

The EVPN and VRF mapping configuration on PE2 establishes mappings between the EVPN identifier and VRF, facilitating efficient routing and connectivity in an EVPN network environment.

PE2(config)#evpn mpls id 2 xconnect target-mpls-id 52	Configure the EVPN-VPWS identifier with a source identifier of 2 and a target identifier of 52.
PE2(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF <code>vrf2</code> to the EVPN-VPWS identifier

PE2(config-evpn-mpls)#commit	Commit the transaction.
PE2(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration

The below access port configuration on PE2 is carried out to create a Layer 2 sub-interface within the port channel interface, set the load balancing, configure system MAC and the encapsulation with VLAN ID, map VPN-ID for efficient network access and connectivity.

PE2(config)#interface po1	Enter the port channel interface mode for po1
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#evpn multi-homed system-mac 0000.aaaa.bbbc	Configure the system-mac address 0000.aaaa.bbbc which plays a role in load balancing.
PE2(config-if)#interface po1.2 switchport	Create a Layer 2 sub-interface po1.2 within the port channel.
PE2(config-if)#encapsulation dot1q 2	Set encapsulation to dot1q with VLAN ID 2.
PE2(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE2(config-acc-if-evpn)#map vpn-id 2	Map VPN-ID 2.
PE2(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE2(config-if)#exit	Exit interface mode po1 and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE3: Loopback Interface

The configuration on PE3 for a loopback interface with IP address 8.8.8.8/32 secondary is set up to provide IP connectivity for the router.

PE3#configure terminal	Enter configure mode.
PE3(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE3(config-if)#ip address 8.8.8.8/32 secondary	Configure a secondary IP address, 8.8.8.8/32, on the loopback interface.
PE3(config-if)#exit	Exit interface mode lo.
PE3(config)#commit	Commit the transaction.

PE3: Global LDP

The configuration on PE3 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE3(config)#router ldp	Enter the Router LDP mode.
PE3(config-router)#router-id 8.8.8.8	Set the router ID for LDP to 7.7.7.7.
PE3(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#targeted-peer ipv4 7.7.7.7	Configure targeted peer for LDP using IPv4 addresses.

PE3(config-router-targeted-peer) #exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router) #exit	Exit router LDP mode and return to the configure mode.
PE3(config) #commit	Commit the transaction.

PE3: Global EVPN MPLS Command

The configuration on PE3 for the Global EVPN MPLS, includes activating EVPN MPLS defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multihoming, and activating EVPN MPLS multihoming functionality, all of which are crucial for enabling EVPN MPLS features.

PE3(config) #evpn mpls enable	Activate the EVPN MPLS functionality on PE3, enabling it to participate in EVPN MPLS services.
PE3(config) #commit	Commit candidate configuration to be running configuration.
PE3(config) #evpn mpls vtep-ip-global 8.8.8.8	Configure the global VTEP IP address 8.8.8.8, associating it with the loopback IP.
PE3(config) #hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multihoming.
PE3(config) #evpn mpls multihoming enable	Activate the EVPN MPLS multihoming functionality, allowing PE3 to support multihomed EVPN MPLS services.
PE3(config) #commit	Commit the transaction.

PE3: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE3 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE3(config) #interface xe5	Enter interface mode xe5.
PE3(config-if) #ip address 124.1.1.2/24	Configure an IP address, 124.1.1.2/24, on the interface xe5.
PE3(config-if) #enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE3(config-if) #label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE3(config-if) #exit	Exit interface mode xe5.
PE3(config) #interface xe4	Enter the interface mode for xe4.
PE3(config-if) #channel-group 1 mode active	Attach LAG interface xe4.
PE3(config-if) #exit	Exit interface mode xe4 and return to the configure mode.
PE3(config) #commit	Commit the transaction.

PE3: OSPF Configuration

The below configuration is performed to set up OSPF on PE3, specifying the router ID and defining network interfaces.

PE3(config) #router ospf 1	Enter the router OSPF mode. Configure PE3 to run OSPF with process ID 1.
PE3(config-router) #ospf router-id 8.8.8.8	Set the OSPF router ID to 8.8.8.8, identifying PE3 within the OSPF network.

PE3(config-router)#network 8.8.8.8/32 area 0.0.0.0	Advertise loopback address in OSPF.
PE3(config-router)#network 124.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
PE3(config-router)#exit	Exit router OSPF mode and return to configure mode.
PE3(config)#commit	Commit the transaction.

PE3: BGP Configuration

The below BGP configuration on PE3 is established to enable BGP routing with ASN 1, set the BGP router ID, define iBGP neighbors, and enable the EVPN address family for efficient routing in an EVPN environment.

PE3(config)#router bgp 1	Enter the Router BGP mode, ASN: 1
PE3(config-router)#bgp router-id 8.8.8.8	Configure BGP router ID 8.8.8.8, identifying PE3 within the BGP network.
PE3(config-router)#neighbor 1.1.1.1 remote-as 1	Configure neighbor 1.1.1.1 as an iBGP neighbor with their remote AS number 1.
PE3(config-router)#neighbor 1.1.1.1 update-source lo	Configure neighbor 1.1.1.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 7.7.7.7 remote-as 1	Configure neighbor 7.7.7.7 as an iBGP neighbor with their remote AS number 1.
PE3(config-router)#neighbor 7.7.7.7 update-source lo	Configure neighbor 7.7.7.7 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE3(config-router-af)#neighbor 1.1.1.1 activate	Activate EVPN for iBGP neighbor 1.1.1.1 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#neighbor 7.7.7.7 activate	Activate EVPN for iBGP neighbor 7.7.7.7 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE3(config-router)#commit	Commit the transaction.
PE3(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE3: MAC VRF Configuration

The below MAC VRF configuration on PE3 is carried out to define and set up VRF named `vrf2` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE3(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE3(config-vrf)#rd 8.8.8.8:2	Configure Route-Distinguisher value of 8.8.8.8:2.
PE3(config-vrf)#route-target both 2:2	Configure import and export values for the vrf2 as 2:2.
PE3(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: EVPN and VRF Mapping

The EVPN and VRF mapping configuration on PE3 establishes mappings between the EVPN identifier and VRF, facilitating efficient routing and connectivity in an EVPN network environment.

PE3(config)#evpn mpls id 2 xconnect target-mpls-id 52	Configure the EVPN-VPWS identifier with a source identifier of 2 and a target identifier of 52.
PE3(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE3(config-evpn-mpls)#commit	Commit the transaction.
PE3(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE3: Access Port Configuration

The below access port configuration on PE3 is carried out to create a Layer 2 sub-interface within the port channel interface, set the load balancing, configure system MAC and the encapsulation with VLAN ID, map VPN-ID for efficient network access and connectivity.

PE3(config)#interface po1	Enter the port channel interface mode for po1
PE3(config-if)#load-interval 30	Set the load interval to 30.
PE3(config-if)#evpn multi-homed system-mac 0000.aaaa.bbbc	Configure the system-mac address 0000.aaaa.bbbc which plays a role in load balancing.
PE3(config-if)#interface po1.2 switchport	Create a Layer 2 sub-interface po1.2 within the port channel.
PE3(config-if)#encapsulation dot1q 2	Set encapsulation to dot1q with VLAN ID 2.
PE3(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE3(config-acc-if-evpn)#map vpn-id 2	Map VPN-ID 2.
PE3(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE3(config-if)#exit	Exit interface mode po1 and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE1: CFM

The following configuration enables CFM monitoring and maintenance for EVPN services on PE1.

PE1(config)#hardware-profile filter cfm-domain-name-str enable	Enable the CFM domain name as a character string profile for CFM filtering.
PE1(config)#ethernet cfm domain-type character-string domain-name evpn1 level 7 mip-creation none	Create a CFM domain for EVPN ELINE with a character string type and set MIP creation to none.
PE1(config-ether-cfm)#service ma-type string ma-name evp1	Define a maintenance association (MA) type with the string evp1.
PE1(config-ether-cfm-ma)#evpn 52	Configure the MA for EVPN ID 52.
PE1(config-ether-cfm-ma)#ethernet cfm mep up mpid 20 active true evpn 52	Create an up-maintenance endpoint (MEP) for local EVPN ID 52.
PE1(config-ether-cfm-ma-mep)#cc multicast state enable	Enable multicast continuity check (CC) state for the MEP.
PE1(config-ether-cfm-ma-mep)#cc interval 100	Set the CC interval to 100 milliseconds.

PE1(config-ether-cfm-ma-mep) #exit-ether-ma-mep-mode	Exit Ethernet MA MEP mode.
PE1(config-ether-cfm-ma) #mep crosscheck mpid 10	Configure cross-check to the remote MEP.
PE1(config-ether-cfm-ma) #exit-ether-ma-mode	Exit Ethernet MA mode.
PE1(config-ether-cfm) #exit	Exit Ethernet CFM mode and return to the configure mode.
PE1(config) #commit	Commit candidate configuration to be running configuration.

PE2/PE3: CFM

The following configuration enables CFM monitoring and maintenance for EVPN services on PE2 and PE3 devices.

Note: Apply the same set of configurations to the PE3 device.

PE2(config) #hardware-profile filter cfm-domain-name-str enable	Enable the CFM domain name as a character string profile for CFM filtering.
PE2(config) #ethernet cfm domain-type character-string domain-name evpn1 level 7 mip-creation none	Create a CFM domain for EVPN ELINE with a character string type and set MIP creation to none.
PE2(config-ether-cfm) #service ma-type string ma-name evp1	Define a maintenance association (MA) type with the string evp1.
PE2(config-ether-cfm-ma) #evpn 2	Configure the MA for EVPN ID 2.
PE2(config-ether-cfm-ma) #ethernet cfm mep up mpid 10 active true evpn 2	Create an up-maintenance endpoint (MEP) for local EVPN ID 2.
PE2(config-ether-cfm-ma-mep) #cc multicast state enable	Enable multicast continuity check (CC) state for the MEP.
PE2(config-ether-cfm-ma-mep) #cc interval 100	Set the CC interval to 100 milliseconds.
PE2(config-ether-cfm-ma-mep) #exit-ether-ma-mep-mode	Exit Ethernet MA MEP mode.
PE2(config-ether-cfm-ma) #mep crosscheck mpid 20	Configure cross-check to the remote MEP.
PE2(config-ether-cfm-ma) #exit-ether-ma-mode	Exit Ethernet MA mode.
PE2(config-ether-cfm) #exit	Exit Ethernet CFM mode and return to the configure mode.
PE2(config) #commit	Commit candidate configuration to be running configuration.

Validation

The following output displays the validation results for PE1, PE2, and PE3 in an EVPN setup, which includes EVPN xconnect status, Ethernet CFM errors, remote maintenance points, local maintenance points, and successful ping tests.

PE1: Display xConnect Status

```
PE1#show evpn mpls xconnect
EVPN Xconnect Info
=====
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up
```

Local			Remote	Connection-Details					
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status
52	----	1500	2	xe33.2	00:00:00:aa:aa:bb:bb:00:00:00	7.7.7.7 8.8.8.8	1500 1500	AC-NW ----	NW-SET ----

PE1: Display Ethernet CFM errors

```
PE1#show ethernet cfm errors domain evpn1
```

Domain Name	Level	MEPID	Defects
evpn1	7	20

PE1: Display Remote Maintenance Points

```
PE1#show ethernet cfm maintenance-points remote domain evpn1 ma-name evpl
```

MEPID	RMEPID	LEVEL	Rx CCM	RDI	PEER-MAC	TYPE
20	10	7	Yes	False	00aa.bb00.0002	Configured

PE1: Display Local Maintenance Points

```
PE1#show ethernet cfm maintenance-points local mep domain evpn1 ma-name evpl
```

MPID	Dir	Lvl	CC-Stat	HW-Status	CC-Intvl	MAC-Address	Def Port	MD Name
20	Up	7	Enable	Installed	100 ms	3417.ebe4.af22 F	xe33.2	evpn1

PE1: Ping Test

```
PE1#ping ethernet mac 00aa.bb00.0002 unicast source 20 domain evpn1 ma evpl
success rate is 100 (5/5)
```

PE2/PE3: Display xConnect Status

```
PE2#show evpn mpls xconnect
```

```
EVPN Xconnect Info
```

```
=====
```

```
AC-AC: Local-Cross-connect
```

```
AC-NW: Cross-connect to Network
```

```
AC-UP: Access-port is up
```

```
AC-DN: Access-port is down
```

```
NW-UP: Network is up
```

```
NW-DN: Network is down
```

```
NW-SET: Network and AC both are up
```

Local			Remote	Connection-Details					
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status
2	----	1500	52	po1.2	--- Single Homed Port ---	1.1.1.1	1500	AC-NW	NW-SET

PE2/PE3: Display Ethernet CFM errors

```
PE2#show ethernet cfm errors domain evpn1
```

Domain Name	Level	MEPID	Defects
evpn1	7	10

PE2/PE3: Display Local Maintenance Points

```
PE2#show ethernet cfm maintenance-points local mep domain evpn1 ma-name evpl
```

MPID	Dir	Lvl	CC-Stat	HW-Status	CC-Intvl	MAC-Address	Def Port	MD Name
10	Up	7	Enable	Installed	100 ms	00aa.bb00.0002 F	po1.2	evpn1

PE2/PE3: Display Remote Maintenance Points

```
PE2#show ethernet cfm maintenance-points remote domain evpn1 ma-name evp1
MEPID      RMEPID      LEVEL      Rx CCM      RDI      PEER-MAC      TYPE
-----
10          20          7          Yes         False    3417.ebe4.af22 Configured
```

PE2/PE3: Ping and Traceroute Test

```
PE2#ping ethernet mac 3417.ebe4.af22 unicast source 10 domain evpn1 ma evp1
success rate is 100 (5/5)
PE2#traceroute ethernet 3417.ebe4.af22 mepid 10 domain evpn1 ma evp1
MP Mac      Hops  Relay-action      Ingress/Egress  Ingress/Egress  action
3417.ebe4.af22 1      RlyHit            Ingress         Ingress         IngOK
```

Implementation Examples

Here is a practical scenario and use case for CFM (802.1ag) implementation for ELINE MultiHoming in the context of a telecommunications service provider who offers Ethernet-based Virtual Private Network (EVPN) services to various enterprises.

Use Case: Ensuring Service Reliability and Quality

Scenario: Consider a company with several branch offices that rely heavily on its ELINE connections to ensure smooth communication and data exchange between offices. The company subscribes to an EVPN service provided by a telecommunications service provider.

Use Case Details

1. **MultiHoming Resilience:** The company's critical applications and services require high availability. MultiHoming ensures redundancy by connecting each branch office to the provider's network through multiple paths. This way, if one path fails due to network issues, the traffic can be rerouted through the alternative path without causing a disruption.
2. **Continuous Monitoring:** CFM implementation allows the service provider to continuously monitor the connectivity and performance of the ELINE connections between the branch offices. By sending CCMs, the provider can quickly identify any interruptions in connectivity.
3. **Swift Issue Detection and Resolution:** In case of a network disruption or fault, the service provider receives immediate alerts through CFM CCMs. This enables the provider's network operations team to pinpoint the issue's location and take prompt action to restore services, minimizing downtime for the company.
4. **Troubleshooting Efficiency:** The CFM Ping and Trace functions assist in troubleshooting network issues. If the company's IT team reports a performance issue or communication problem, use CFM diagnostic capabilities to trace the path of packets and identify bottlenecks or faulty segments.

In this use case, the CFM implementation for ELINE MultiHoming provides a robust solution for ensuring reliable and high-quality connectivity for the company's distributed offices. It enables proactive monitoring and rapid issue resolution, which are critical for maintaining the company's communication and operational efficiency.

Troubleshooting

Follow the troubleshooting steps below to resolve connectivity issues related to CFM EVPN-ID and crosscheck local and remote MEP ID matching.

1. **Check Local EVPN-ID:** Verify the EVPN-ID configured on the local device (Example: PE1) and ensure that it matches the intended EVPN-ID for the target service or connection.

2. **Verify Remote EVPN-ID:** Check the EVPN-ID configured on the remote device (Example: PE2) and confirm that it matches the EVPN-ID expected by the local device.
3. **Crosscheck MEP ID:** Examine the MEP ID configured on the local device (PE1) and ensure it matches the expected R-MEP ID on the remote device (PE2).
4. **Validate Remote MEP ID:** Verify the MEP ID configured on the remote device (PE2) and ensure it matches the R-MEP ID expected by the local device (PE1).
5. **Reconfigure If Needed:** If there are discrepancies between the local and remote EVPN-IDs or MEP IDs, reconfigure the devices to match.
6. **Test the Connection:** After ensuring that EVPN-IDs and MEP IDs match on both devices, test the connection to confirm it is established correctly.

Abbreviations

The following are some key abbreviations and their meanings relevant to this document:

Acronym	Description
CFM	Continuity Fault Management
CCM	Continuity Check Messages
EVPN	Ethernet Virtual Private Network
ELINE	Ethernet-LINE
MPLS	Multi-Protocol Label Switching
UP	User-to-Provider
MEP	Maintenance End Point
MH	MultiHoming
R-MEP	Remote Maintenance End Point
MAC	Media Access Control
AC	Access Circuit
TLV	Type-Length-Value
RDI	Remote Defect Indicator
LB	Loopback
LBM	Loopback Message
LTR	Looptrace Reply

Glossary

The following provides definitions for key terms used throughout this document.

Continuity Fault Management (CFM)	A protocol (802.1ag) that facilitates the monitoring of network connectivity by using Continuity Check Messages (CCM) to detect faults.
Continuity Check Messages (CCM)	Periodic messages are used in CFM to check the continuity of a network connection.
Ethernet Virtual Private Network (EVPN)	A technology that enables the extension of Layer 2 Ethernet networks over a Layer 3 infrastructure.
Multi-Protocol Label Switching (MPLS)	In telecommunications networks, a routing technique is employed to guide data from one node to the next using concise path labels rather than relying on lengthy network addresses.
User-to-Provider (UP)	Refers to the connection between the user's and service provider's networks.
Maintenance End Point (MEP)	A point in a network where maintenance operations are initiated or terminated.
MultiHoming (MH)	A networking architecture that allows a device to be connected to multiple network paths or points of attachment.
Remote Maintenance End Point (R-MEP)	A maintenance end point located remotely from the originating point.
Media Access Control (MAC)	A unique identifier assigned to a network interface card.
Attachment Circuit (AC)	A circuit that connects a customer's equipment to a provider's network.
Type-Length-Value (TLV)	A format used to encapsulate data in a variety of protocols.
Remote Defect Indication (RDI)	A signal used to indicate a fault condition in a network link.
Loopback Message (LBM)	A message used in loopback testing to check connectivity.

CHAPTER 11 Inter-AS VPN Configuration Overview

MPLS VPN architecture typically runs within an AS. Routes of any VPN can be flooded within the AS, but not to other ASs. To implement the exchange of VPN routes between different ASs, the inter-AS MPLS VPN model is used. The inter-AS MPLS VPN model is an extension to MPLS VPN framework. Route prefixes and labels can be advertised over links between different carrier networks through the inter-AS MPLS model.

The MPLS VPN solution serves an increasing number of users across many applications. A site at one geographical location often needs to connect to an ISP network at another geographical location. In this situation, for example, inter-AS issues may arise for operators who manage different metropolitan area networks (MANs) or backbone networks that span different autonomous systems (AS).

Types of Inter-AS VPN

1. Inter-AS VPN Option A: Autonomous system boundary routers (ASBRs) manage VPN routes for in-ter-AS VPNs through dedicated interfaces.
2. Inter-AS VPN Option B: ASBRs advertise labeled VPN-IPv4 routes to each other through MP-EBGP.
3. Inter-AS VPN Option C: PE devices advertise labeled VPN-IPv4 routes to each other through Mul-ti-hop MP-EBGP.

CHAPTER 12 Inter-AS VPN Option-A Configuration

This chapter explain about Inter-AS VPN Option-A. Option A is the simplest of the options to inter-connect the ASBRs. Option A has the following characteristics:

- Each customer VRF requires either a physical interface or more likely a subinterface.
- Each ASBR thinks the other is a CE.
- One logical interface per VPN.
- Link may use any supported PE-CE protocol.
- Packets are sent unlabelled between the ASBRs.
- The most secure and easy option to provision.
- Does not scale well to a large number of VPNs.

Topology

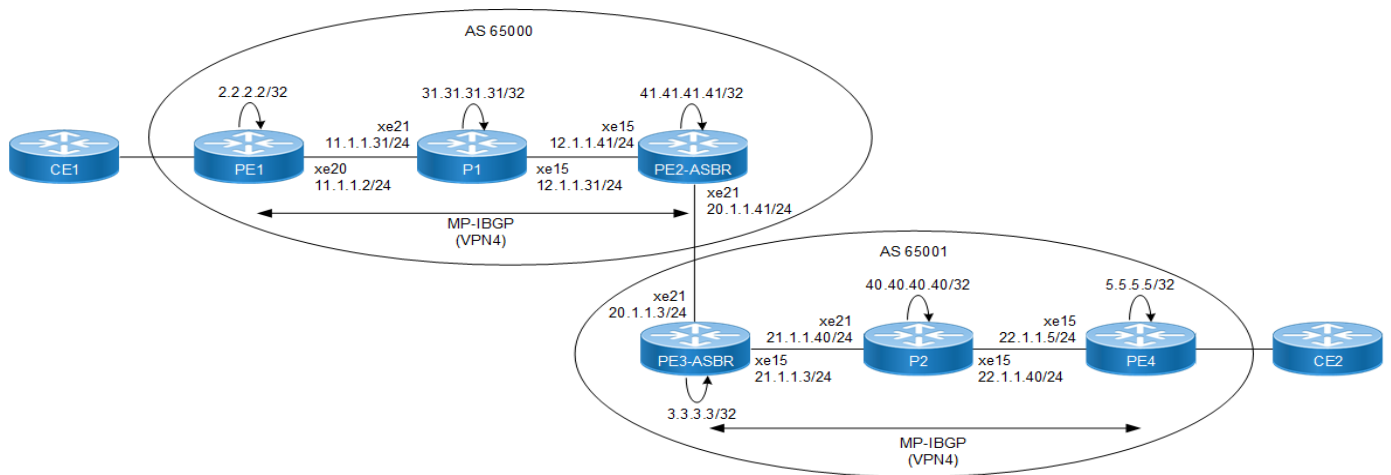


Figure 12-3: InterAS-VPN Option-A

PE1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#ip vrf vrf1	Create a new VRF named vrf1.
(config-vrf)#rd 1:1	Assign the route distinguisher (RD) value as 1:1.
(config-vrf)#route-target both 1:1	Import routes between route target (RT) ext-communities.
(config-vrf)#exit	Exit interface mode.
(config)#interface xe22	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Bind the interface connected to the CE router with VRF vrf1
(config-if)#ip address 10.1.1.2/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode

(config)#interface xe20	Enter interface mode
(config-if)#ip address 11.1.1.2/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 2.2.2.2	Configure OSPF router id same as loopback ip address.
(config-router)#network 2.2.2.2/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 11.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 2.2.2.2	Configure the router ID same as loopback IP address.
(config-router)#transport-address ipv4 2.2.2.2	Configure LDP transport address same as loopback address.
(config-router)#exit	Exit LDP mode.
(config)#interface xe20	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#exit	Exit interface mode.
(config)#router bgp 65000	Enter BGP router mode.
(config-router)#bgp router-id 2.2.2.2	Configure BGP router-id.
(config-router)#neighbor 41.41.41.41 remote-as 65000	Configure PE2-ASBR1 as an iBGP peer.
(config-router)#neighbor 41.41.41.41 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 41.41.41.41 activate	Activate the PE neighbor so that it can accept VPN IPv4 routes.
(config-router-af)#exit	Exit VPNv4 address family mode.
(config-router)#address-family ipv4 vrf vrf1	Enter the IPv4 address family for VRF vrf1.
(config-router-af)#redistribute connected	Redistribute connected route.
(config-router-af)#commit	Commit the transaction.
(config-router-af)#exit	Exit VPNv4 address family mode.
(config-router)#exit	Exit OSPF router mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

P1 Configuration

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 31.31.31.31/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.

(config)#interface xe21	Enter interface mode.
(config-if)#ip address 11.1.1.31/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 12.1.1.31/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 31.31.31.31	Configure OSPF router ID same as loopback IP address.
(config-router)#network 31.31.31.31/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 11.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 12.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 31.31.31.31	Configure the router id same as loopback ip address.
(config-router)#transport-address ipv4 31.31.31.31	Configure LDP transport address same as loopback address.
(config-router)#exit	Exit LDP mode.
(config)#interface xe21	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-router)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#commit	Commit the transaction.
(config-if)#exit	Exit interface mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

PE2-ASBR1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 41.41.41.41/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#ip vrf vrf1	Create a new VRF named vrf1.
(config-vrf)#rd 1:1	Assign the route distinguisher (RD) value as 1:1.
(config-vrf)#route-target both 1:1	Import routes between route target (RT) ext-communities.
(config-vrf)#exit	Exit interface mode.

(config)#interface xe21	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Bind the interface connected to the CE router with VRF vrf1.
(config-if)#ip address 20.1.1.41/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 12.1.1.41/24	Assign the IPv4 address.
(config-if)#	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 41.41.41.41	Configure OSPF router ID same as loopback IP address.
(config-router)#network 41.41.41.41/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 12.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#transport-address ipv4 41.41.41.41	Configure LDP transport address same as loopback address.
(config-router)#exit	Exit LDP mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-router)#exit	Exit interface mode.
(config)#router bgp 65000	Enter BGP router mode.
(config-router)#bgp router-id 41.41.41.41	Configure BGP router-id.
(config-router)#neighbor 2.2.2.2 remote-as 65000	Configure PE1 as an iBGP peer.
(config-router)#neighbor 2.2.2.2 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 2.2.2.2 activate	Activate the PE neighbor so that it can accept VPN IPv4 routes.
(config-router-af)#exit	Exit VPNv4 address family mode.
(config-router)#address-family ipv4 vrf vrf1	Enter the IPv4 address family for VRF vrf1.
(config-router-af)#neighbor 20.1.1.3 remote-as 65001	Configure eBGP neighbor.
(config-router-af)#redistribute connected	Redistribute connected route.
(config-router-af)#commit	Commit the transaction.
(config-router-af)#exit-address-family	Exit address family mode.
(config-router)#exit	Exit the router mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

PE3-ASBR2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 3.3.3.3/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#ip vrf vrf1	Create a new VRF named vrf1.
(config-vrf)#rd 1:1	Assign the route distinguisher (RD) value as 1:1.
(config-vrf)#route-target both 1:1	Import routes between route target (RT) ext-communities.
(config-vrf)#exit	Exit interface mode.
(config)#interface xe21	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Bind the interface connected to the CE router with VRF vrf1.
(config-if)#ip address 20.1.1.3/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 21.1.1.3/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 3.3.3.3	Configure OSPF router id same as loopback ip address.
(config-router)#network 3.3.3.3/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 21.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 3.3.3.3	Configure the router ID same as loopback IP address.
(config-router)#transport-address ipv4 3.3.3.3	Configure LDP transport address same as loopback address.
(config-router)#exit	Exit LDP mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-router)#exit	Exit interface mode.
(config)#router rsvp	Enter router RSVP mode.
(config-router)#rsvp-trunk lsp1	Create an RSVP trunk lsp1 and enter the Trunk mode.
(config-trunk)#to 5.5.5.5	Specify the IPv4 egress (destination point-PE4 loopback address) for the LSP.
(config-trunk)#exit	Exit interface mode.
(config)#router bgp 65001	Enter BGP router mode.
(config-router)#bgp router-id 3.3.3.3	Configure BGP router-id.
(config-router)#neighbor 5.5.5.5 remote-as 65001	Configure PE4 as an iBGP peer.

(config-router)#neighbor 5.5.5.5 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 5.5.5.5 activate	Activate the PE neighbor so that it can accept VPN IPv4 routes.
(config-router-af)#exit	Exit VPNv4 address family mode.
(config-router)#address-family ipv4 vrf vrf1	Enter the IPv4 address family for VRF vrf1.
(config-router-af)#neighbor 20.1.1.41 remote-as 65000	Configure eBGP neighbor.
(config-router-af)#neighbor 20.1.1.41 activate	Activate the eBGP neighbor under address family.
(config-router-af)#redistribute connected	Redistribute connected route.
(config-router-af)#commit	Commit the transaction.
(config-router-af)#exit-address-family	Exit address family mode.
(config-router)#exit	Exit the router mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

P2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 40.40.40.40/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe21	Enter interface mode.
(config-if)#ip address 21.1.1.40/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 22.1.1.40/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 40.40.40.40	Configure OSPF router ID same as loopback IP address.
(config-router)#network 40.40.40.40/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 21.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 22.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 40.40.40.40	Configure the router ID same as loopback IP address.
(config-router)#transport-address ipv4 40.40.40.40	Configure LDP transport address same as loopback address.
(config-router)#exit	Exit LDP mode.

(config)#interface xe21	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#commit	Commit the transaction.
(config-if)#exit	Exit interface mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

PE4

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 5.5.5.5/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#ip vrf vrf1	Create a new VRF named vrf1.
(config-vrf)#rd 1:1	Assign the route distinguisher (RD) value as 1:1.
(config-vrf)#route-target both 1:1	Import routes between route target (RT) ext-communities.
(config-vrf)#exit	Exit VRF mode.
(config)#interface xe22	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Bind the interface connected to the CE router with VRF vrf1.
(config-if)#ip address 30.1.1.5/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 22.1.1.5/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 5.5.5.5	Configure OSPF router ID same as loopback IP address.
config-router)#network 5.5.5.5/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 22.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit router OSPF mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 5.5.5.5	Configure the router ID same as loopback IP address.
(config-router)#transport-address ipv4 5.5.5.5	Configure LDP transport address same as loopback address.
(config-router)#exit	Exit LDP mode.
(config)#interface xe15	Enter interface mode.

(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#exit	Exit interface mode.
(config)#router bgp 65001	Enter BGP router mode.
(config-router)#bgp router-id 5.5.5.5	Configure BGP router-id.
(config-router)#neighbor 3.3.3.3 remote-as 65001	Configure PE2-ASBR1 as an iBGP peer.
(config-router)#neighbor 3.3.3.3 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 3.3.3.3 activate	Activate neighbor.
(config-router-af)#exit	Exit VPNv4 Address Family mode.
(config-router)#address-family ipv4 vrf vrf1	Enter IPv4 VRF Address Family mode.
(config-router-af)#redistribute connected	Redistribute connected route.
(config-router-af)#commit	Commit the transaction.
(config-router-af)#exit-address-family	Exit address family mode.
(config-router)#exit	Exit the router mode
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

Validation

PE1

```
#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info
```

IP Route Table for VRF "vrf1"

```
C    *> 10.1.1.0/24 is directly connected, xe22, 01:05:28
B    *> 20.1.1.0/24 [200/0] via 41.41.41.41, 00:01:18
B    *> 30.1.1.0/24 [200/0] via 41.41.41.41, 00:00:24
C    *> 127.0.0.0/8 is directly connected, lo.vrf1, 01:06:20
```

Gateway of last resort is not set

```
#show ip bgp vpnv4 all
```

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, l - labeled

S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (Default for VRF vrf1)					

```

*> 1 10.1.1.0/24      0.0.0.0          0          100          32768      ?
*>i  20.1.1.0/24      41.41.41.41         0          100          0          ?
*>i  30.1.1.0/24      41.41.41.41         0          100          0
65001 ?
  Announced routes count = 1
  Accepted routes count = 2
Route Distinguisher: 1:1
*>i  20.1.1.0/24      41.41.41.41         0          100          0          ?
*>i  30.1.1.0/24      41.41.41.41         0          100          0
65001 ?
  Announced routes count = 0
  Accepted routes count = 2

```

PE2-ASBR1

```

#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info

```

IP Route Table for VRF "vrf1"

```

C    *> 20.1.1.0/24 is directly connected, xe22, 01:05:28
B    *> 10.1.1.0/24 [200/0] via 2.2.2.2, 00:01:18
B    *> 30.1.1.0/24 [20/0] via 20.1.1.3, xe2, 00:54:13
C    *> 127.0.0.0/8 is directly connected, lo.vrf1, 01:06:20

```

Gateway of last resort is not set

```

#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

```

```

      Network      Next Hop      Metric      LocPrf      Weight Path
Route Distinguisher: 1:1 (Default for VRF vrf1)
*>i  10.1.1.0/24    2.2.2.2          0          100          0          ?
*> 1 20.1.1.0/24    0.0.0.0          0          100          32768      ?
*   20.1.1.0/24    20.1.1.3         0          100          0
65001 ?
*> 1 30.1.1.0/24    20.1.1.3         0          100          0
65001 ?
  Announced routes count = 3
  Accepted routes count = 1
Route Distinguisher: 1:1
*>i  10.1.1.0/24    2.2.2.2          0          100          0          ?
  Announced routes count = 0
  Accepted routes count = 1

```

PE3-ASBR2

```

#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area

```

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
 E1 - OSPF external type 1, E2 - OSPF external type 2
 i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
 ia - IS-IS inter area, E - EVPN,
 v - vrf leaked
 > - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"

```
B    *> 10.1.1.0/24 [20/0] via 20.1.1.41, xe22, 00:55:54
C    *> 20.1.1.0/24 is directly connected, xe22, 01:05:28
B    *> 30.1.1.0/24 [200/0] via 5.5.5.5, 00:01:18
C    *> 127.0.0.0/8 is directly connected, lo.vrf1, 01:06:20
```

Gateway of last resort is not set

#show ip bgp vpnv4 all

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, l - labeled

S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (Default for VRF vrf1)					
*> 1 10.1.1.0/24	20.1.1.41	0	100	0	
65000 ?					
*> 1 20.1.1.0/24	0.0.0.0	0	100	32768	?
* 20.1.1.0/24	20.1.1.41	0	100	0	
65000 ?					
*>i 30.1.1.0/24	5.5.5.5	0	100	0	?
Announced routes count = 3					
Accepted routes count = 1					
Route Distinguisher: 1:1					
*>i 30.1.1.0/24	5.5.5.5	0	100	0	?
Announced routes count = 0					
Accepted routes count = 1					

PE4

#show ip route vrf vrf1 database

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP

O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,

ia - IS-IS inter area, E - EVPN,

v - vrf leaked

> - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"

```
B    *> 10.1.1.0/24 [200/0] via 3.3.3.3, 00:00:08
B    *> 20.1.1.0/24 [200/0] via 3.3.3.3, 00:02:45
C    *> 30.1.1.0/24 is directly connected, xe18, 01:02:20
C    *> 127.0.0.0/8 is directly connected, lo.vrf1, 01:05:36
```

Gateway of last resort is not set

#show ip bgp vpnv4 all

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, l - labeled

```

      S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

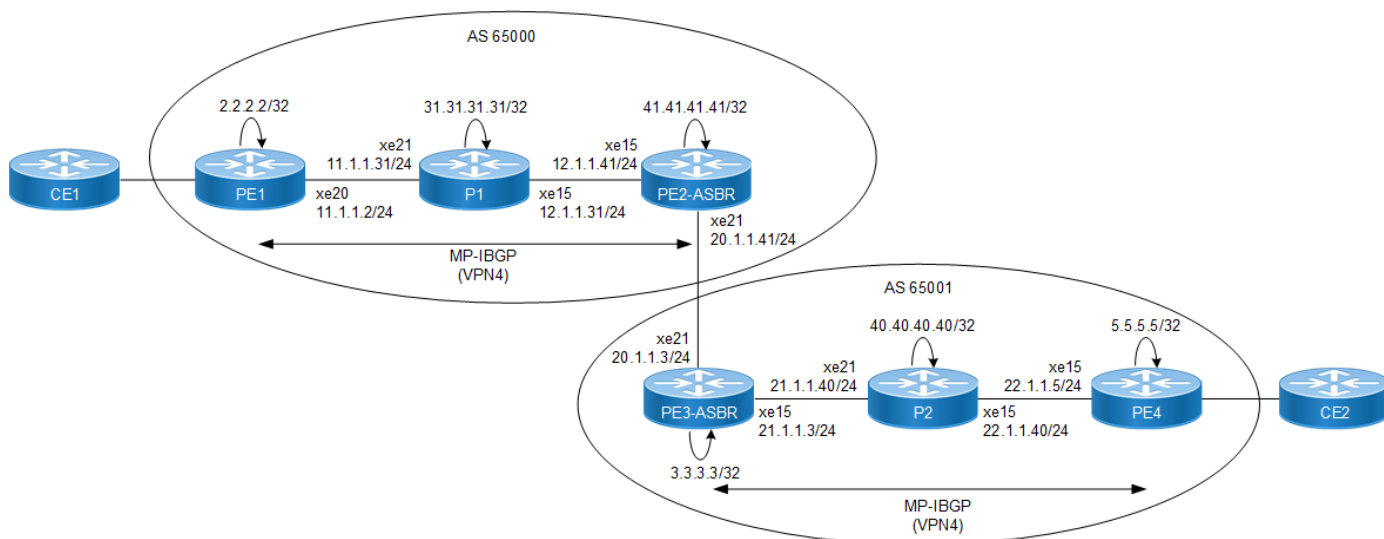
      Network      Next Hop      Metric      LocPrf      Weight Path
Route Distinguisher: 1:1 (Default for VRF vrf1)
*>i 10.1.1.0/24      3.3.3.3      0           100          0
65000 ?
*>i 20.1.1.0/24      3.3.3.3      0           100          0          ?
*> 1 30.1.1.0/24      0.0.0.0      0           100          32768        ?
  Announced routes count = 1
  Accepted routes count = 2
Route Distinguisher: 1:1
*>i 10.1.1.0/24      3.3.3.3      0           100          0
65000 ?
*>i 20.1.1.0/24      3.3.3.3      0           100          0          ?
  Announced routes count = 0
  Accepted routes count = 2
```

CHAPTER 13 Inter-AS VPN Option-B Configuration

- Inter-AS Option B is a more scalable solution compared to Option A. It does not require any VRFs on the ASBRs, it uses VPNv4 eBGP to exchange VPNv4 updates.
- Single interface to connect the ASBRs.
- Packets are sent labelled between the ASBRs.
- No need for VRFs on the ASBR.
- ASBRs must be directly connected.
- Scales better than Option A.

Note: ASBR BGP label allocation mode uses per-prefix label allocation, and per-VRF label allocation cannot be achieved in ASBRs (VPNv4 and VPNv6).

Topology



PE1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#ip vrf vrf1	Create a new VRF named vrf1.
(config-vrf)#rd 1:1	Assign the route distinguisher (RD) value as 1:1.
(config-vrf)#route-target both 1:1	Import routes between route target (RT) ext-communities.
(config-vrf)#exit	Exit VRF mode.
(config)#interface xe22	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Bind the interface connected to the CE router with VRF vrf1.
(config-if)#ip address 10.1.1.2/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.

(config)#interface xe20	Enter interface mode.
(config-if)#ip address 11.1.1.2/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 2.2.2.2	Configure OSPF router id same as loopback ip address.
(config-router)#network 2.2.2.2/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 11.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address
(config-router)#targeted-peer ipv4 41.41.41.41	Configure targeted peer.
(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted peer.
(config-router-targeted-peer)#targeted-peer ipv4 5.5.5.5	Configure targeted peer.
(config-router-targeted-peer)#targeted-peer ipv4 41.41.41.41	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode.
(config-router)#exit	Exit router mode
(config)#interface xe20	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#exit	Exit interface mode.
(config)#router bgp 65000	Enter BGP router mode.
(config-router)#bgp router-id 2.2.2.2	Configure BGP router-id.
(config-router)#neighbor 41.41.41.41 remote-as 65000	Configure PE2-ASBR1 as an iBGP peer.
(config-router)#neighbor 41.41.41.41 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 41.41.41.41 activate	Activate the PE neighbor so that it can accept VPN IPv4 routes.
(config-router-af)#exit	Exit VPNv4 address family mode.
(config-router)#address-family ipv4 vrf vrf1	Enter the IPv4 address family for VRF vrf1.
(config-router-af)#redistribute connected	Redistribute connected route.
(config-router-af)#commit	Commit the transaction.
(config-router-af)#exit-address-family	Exit address family mode.
(config-router)#exit	Exit the router mode.

(config) #commit	Commit candidate configuration to be running configuration.
(config) #exit	Exit the config mode.

P1

#configure terminal	Enter configure mode.
(config) #interface lo	Enter interface mode.
(config-if) #ip address 31.31.31.31/32 secondary	Assign the IPv4 address.
(config-if) #exit	Exit interface mode.
(config) #interface xe21	Enter interface mode.
(config-if) #ip address 11.1.1.31/24	Assign the IPv4 address.
(config-if) #exit	Exit interface mode.
(config) #interface xe15	Enter interface mode.
(config-if) #ip address 12.1.1.31/24	Assign the IPv4 address.
(config-if) #exit	Exit interface mode.
(config) #router ospf 1	Enter router OSPF mode.
(config-router) #ospf router-id 31.31.31.31	Configure OSPF router id same as loopback ip address.
(config-router) #network 31.31.31.31/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router) #network 11.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router) #network 12.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router) #exit	Exit OSPF router mode.
(config) #router ldp	Enter router LDP mode.
(config-router) #router-id 31.31.31.31	Set the router ID to IP address 31.31.31.31
(config-router) #transport-address ipv4 31.31.31.31	Configure LDP transport address same as loopback address.
(config-router) #exit	Exit LDP mode.
(config) #interface xe21	Enter interface mode.
(config-if) #label-switching	Enable label switching in interface.
(config-if) #enable-ldp ipv4	Enable LDP in interface.
(config-if) #exit	Exit interface mode.
(config) #interface xe15	Enter interface mode.
(config-if) #label-switching	Enable label switching in interface.
(config-if) #enable-ldp ipv4	Enable LDP in interface.
(config-if) #commit	Commit the transaction.
(config-if) #exit	Exit interface mode.
(config) #commit	Commit candidate configuration to be running configuration.
(config) #exit	Exit the config mode.

PE2-ASBR

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 41.41.41.41/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 41.41.41.41	Set the router ID to IP address 41.41.41.41
(config-router)#transport-address ipv4 41.41.41.41	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 2.2.2.2	Configure targeted peer.
(config-router-targeted-peer)#targeted-peer ipv4 3.3.3.3	Configure targeted peer.
(config-router-targeted-peer)#targeted-peer ipv4 5.5.5.5	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 12.1.1.41/24	Assign ipv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 41.41.41.41	Configure OSPF router id same as loopback ip address.
(config-router)#network 41.41.41.41/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 12.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe21	Enter interface mode.
(config-if)#ip address 20.1.1.41/24	Assign the IPv4 address.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#exit	Exit interface mode.
(config)#router bgp 65000	Enter BGP router mode.
(config-router)#bgp router-id 41.41.41.41	Configure BGP router-id.
(config-router)#no bgp inbound-route-filter	Disable inbound route filter.
(config-router)#neighbor 2.2.2.2 remote-as 65000	Configure PE1 as an iBGP peer.

(config-router)#neighbor 2.2.2.2 update-source lo	Update the source as loopback for iBGP peering with the remote PE1 router.
(config-router)#neighbor 20.1.1.3 remote-as 65001	Configure eBGP neighbor with ASBR2.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 2.2.2.2 activate	Activate the PE neighbor so that it can accept VPN IPv4 routes.
(config-router-af)#neighbor 2.2.2.2 next-hop-self	Configure this to make the router the next hop for a BGP neighbor.
(config-router-af)#neighbor 20.1.1.3 activate	Activate the ASBR eBGP neighbor.
(config-router-af)#neighbor 20.1.1.3 allow-ebgp-vpn	Configure this to allow exchange of VPN updates between eBGP peers.
(config-router-af)#neighbor 20.1.1.3 activate	Activate the ASBR eBGP neighbor.
(config-router-af)#commit	Commit candidate configuration to the running configuration.

PE3-ASBR

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 3.3.3.3/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 3.3.3.3	Set the router ID to IP address 3.3.3.3
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 2.2.2.2	Configure targeted peer.
(config-router-targeted-peer)#targeted-peer ipv4 41.41.41.41	Configure targeted peer.
(config-router-targeted-peer)#targeted-peer ipv4 5.5.5.5	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#interface xe21	Enter interface mode.
(config-if)#ip address 20.1.1.3/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 21.1.1.3/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 3.3.3.3	Configure OSPF router id same as loopback ip address.
(config-router)#network 3.3.3.3/32 area 0	Define the network on which OSPF runs and associate area id.

(config-router)#network 21.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#router ldp	Enter router ldp mode.
(config-router)#transport-address ipv4 3.3.3.3	Configure LDP transport address same as loopback address
(config-router)#exit	Exit LDP mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-router)#exit	Exit LDP mode.
(config)#interface xe21	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#exit	Exit interface mode.
(config)#router bgp 65001	Enter BGP router mode.
(config-router)#bgp router-id 3.3.3.3	Configure BGP router-id.
(config-router)#no bgp inbound-route-filter	Disable inbound route filter.
(config-router)#neighbor 5.5.5.5 remote-as 65001	Configure PE4 as an iBGP peer.
(config-router)#neighbor 5.5.5.5 update-source lo	Update the source as loopback for iBGP peering with the remote PE1 router.
(config-router)#neighbor 20.1.1.41 remote-as 65000	Configure eBGP neighbor with PE4.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 5.5.5.5 activate	Activate the PE neighbor so that it can accept VPN IPv4 routes.
(config-router-af)#neighbor 5.5.5.5 next-hop-self	Configure this to make the router the next hop for a BGP neighbor.
(config-router-af)#neighbor 20.1.1.41 activate	Activate the ASBR eBGP neighbor.
(config-router-af)#neighbor 20.1.1.41 allow-ebgp-vpn	Configure this to allow exchange of vpn updates between eBGP peers.
(config-router-af)#neighbor 20.1.1.41 activate	Activate the ASBR eBGP neighbor.
(config-router-af)#commit	Commit candidate configuration to be running configuration.

P2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 40.40.40.40/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 40.40.40.40	Set the router ID to IP address 40.40.40.40

(config-router)#transport-address ipv4 40.40.40.40	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 40.40.40.40	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#interface xe21	Enter interface mode.
(config-if)#ip address 21.1.1.40/24	Assign the IPv4 address.
(config-if)#exit (config-router)#targeted-peer ipv4 40.40.40.40	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 22.1.1.40/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 40.40.40.40	Configure OSPF router id same as loopback ip address.
(config-router)#network 40.40.40.40/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 21.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 22.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#transport-address ipv4 40.40.40.40	Configure LDP transport address same as loopback address.
(config-router)#exit	Exit LDP mode.
(config)#interface xe21	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable ldp in interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#commit	Commit the transaction.
(config-if)#exit	Exit interface mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

PE4

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 5.5.5.5/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 5.5.5.5	Set the router ID to IP address 5.5.5.5
(config-router)#transport-address ipv4 5.5.5.5	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 5.5.5.5	Configure targeted peer.
(config-router-targeted-peer)# targeted-peer ipv4 2.2.2.2	Configure targeted peer.
(config-router-targeted-peer)# targeted-peer ipv4 41.41.41.41	Configure targeted peer.
(config-router-targeted-peer)# targeted-peer ipv4 3.3.3.3	Configure targeted peer.
(config-router)#exit	Exit router mode
(config)#ip vrf vrf1	Create a new VRF named vrf1.
(config-vrf)#rd 1:1	Assign the route distinguisher (RD) value as 1:1.
(config-vrf)#route-target both 1:1	Import routes between route target (RT) ext-communities.
(config-vrf)#exit	Exit VRF mode.
(config)#interface xe22	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Bind the interface connected to the CE router with VRF vrf1.
(config-if)#ip address 30.1.1.5/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 22.1.1.5/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 5.5.5.5	Configure OSPF router id same as loopback ip address.
(config-router)#network 5.5.5.5/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 22.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#exit	Exit interface mode.
(config)#router bgp 65001	Enter BGP router mode.

(config-router)#bgp router-id 5.5.5.5	Configure BGP router-id.
(config-router)#neighbor 3.3.3.3 remote-as 65001	Configure PE2-ASBR1 as an iBGP peer.
(config-router)#neighbor 3.3.3.3 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 3.3.3.3 activate	Activate the PE neighbor so that it can accept VPN IPv4 routes.
(config-router-af)#exit	Exit VPNv4 address family mode.
(config-router)#address-family ipv4 vrf vrf1	Enter the IPv4 address family for VRF vrf1.
(config-router-af)#redistribute connected	Redistribute connected route.
(config-router-af)#commit	Commit the transaction.
(config-router-af)#exit-address-family	Exit address family mode.
(config-router)#exit	Exit the router mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

Validation

PE1

```
PE1#sh ldp session
Peer IP Address    IF Name    My Role    State          KeepAlive    UpTime
31.31.31.31        xe20       Passive    OPERATIONAL    30           00:49:02
```

```
#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info
```

```
IP Route Table for VRF "vrf1"
C    *> 10.1.1.0/24 is directly connected, xe22, 03:49:26
B    *> 30.1.1.0/24 [200/0] via 41.41.41.41, 00:00:41
C    *> 127.0.0.0/8 is directly connected, lo.vrf1, 03:50:18
```

```
PE1#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
```

```
Network          Next Hop          Metric    LocPrf    Weight Path
Route Distinguisher: 1:1 (Default for VRF vrf1)
```



```

*> 1 10.1.1.0/24      0.0.0.0      0      100      32768      ?
*>i 30.1.1.0/24      41.41.41.41    0      100      0
65001 ?
  Announced routes count = 1
  Accepted routes count = 1
Route Distinguisher: 1:1
*>i 30.1.1.0/24      41.41.41.41    0      100      0
65001 ?
  Announced routes count = 0
  Accepted routes count = 1

```

PE2-ASBR1

```
PE2-ASBR2#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
31.31.31.31	xe47	Active	OPERATIONAL	30	00:16:22
3.3.3.3	xe45	Active	OPERATIONAL	30	00:14:54

```
#show ip bgp vpnv4 all
```

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, l - labeled

S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1					
*>i 10.1.1.0/24	2.2.2.2	0	100	0	?
*> 1 30.1.1.0/24	20.1.1.3	0	100	0	
65001 ?					
Announced routes count = 0					
Accepted routes count = 2					

```
#show ip bgp vpnv4 all summary
```

BGP router identifier 41.41.41.41, local AS number 65000

BGP table version is 4

2 BGP AS-PATH entries

0 BGP community entries

Neighbor	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
Down State/PfxRcd								
2.2.2.2	4	65000	168	171	4	0	0	
00:29:03	1							
20.1.1.3	4	65001	111	119	4	0	0	
00:42:51	1							

Total number of neighbors 2

Total number of Established sessions 2

PE3-ASBR2

```
PE3-ASBR2#sh ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
41.41.41.41	xe45	Passive	OPERATIONAL	30	00:15:47
40.40.40.40	xe6	Passive	OPERATIONAL	30	00:24:32

```
#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1					
*> 1 10.1.1.0/24	20.1.1.41	0	100	0	
65000 ?					
*>i 1 30.1.1.0/24	5.5.5.5	0	100	0	?
Announced routes count = 0					
Accepted routes count = 2					

```
#show ip bgp vpnv4 all summary
BGP router identifier 3.3.3.3, local AS number 65001
BGP table version is 4
2 BGP AS-PATH entries
0 BGP community entries
```

Neighbor	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
Down State/PfxRcd								
5.5.5.5	4	65001	41	45	4	0	0	
00:15:59	1							
20.1.1.41	4	65000	115	118	4	0	0	
00:43:58	1							

```
Total number of neighbors 2
Total number of Established sessions 2
```

PE4

```
#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (Default for VRF vrfl)					
*>i 10.1.1.0/24	3.3.3.3	0	100	0	
65000 ?					
*> 1 30.1.1.0/24	0.0.0.0	0	100	32768	?
Announced routes count = 1					
Accepted routes count = 1					
Route Distinguisher: 1:1					
*>i 10.1.1.0/24	3.3.3.3	0	100	0	
65000 ?					
Announced routes count = 0					
Accepted routes count = 1					

```
#show ip route vrf vrfl database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
```

ia - IS-IS inter area, E - EVPN,
v - vrf leaked
> - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"

B *> 10.1.1.0/24 [200/0] via 3.3.3.3, 00:00:48
C *> 30.1.1.0/24 is directly connected, xe22, 03:46:38
C *> 127.0.0.0/8 is directly connected, lo.vrf1, 03:49:54

Gateway of last resort is not set

PE4#sh ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
40.40.40.40	xe5	Passive	OPERATIONAL	30	00:26:30

P#sh ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe7	Active	OPERATIONAL	30	00:31:27
41.41.41.41	xe1	Passive	OPERATIONAL	30	00:15:12

P#

P2#sh ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
3.3.3.3	xe6	Active	OPERATIONAL	30	00:24:58
5.5.5.5	xe5	Active	OPERATIONAL	30	00:24:15

CHAPTER 14 Inter-AS VPN Option-C Configuration

This is an option which enables BGP VPNv4 routes exchange between the two or more Provider Edge routers residing in different AS'es. There is no VPNv4 route exchange between the ASBRs and hence the ASBRs are completely transparent of the VPNs provisioned on the connecting AS'es. This option is more scalable than the previous two options because it removes the restriction of installing VPNv4 LFIB entries on the ASBRs hence reducing the resource requirements on them. ASBRs are only required to forward data based on the transport LSPs configured.

Pre-requisites to successfully configure this option.

- There should be end to end transport LSP between the two PE's residing in different AS'es.
- Could use BGP Labeled-unicast to exchange labels for the two PE's residing in different AS'es.
- This option can utilize RR's to exchange VPNv4 routes between the two AS'es and hence should have capability to keep the next-hops unchanged when reflecting routes from iBGP to eBGP
- LDP/RSVP/SR can be used as a transport within the AS.

There are multiple ways in which this option can be configured.

- Inter-AS Option-C with VPNv4 Routes exchange between the two RRs in different AS'es
- Inter-AS Option-C with VPNv4 Routes exchange between two PE's in different AS.
- Inter-AS Option-C with VPNv4 Routes exchange between PE of one AS and RR of another AS.

This section explains the configuration for the first two points.

Inter-AS Option-C with RR

This sub-option enables VPNv4 routes exchange between the Route-Reflectors of different AS'es and thus requires

1. Remote PE loopback addresses to be known in the AS - This is accomplished using BGP-LU and is advertised inside the AS using the Route-reflector and outside the AS using the eBGP Peering between the ASBRs.
 2. MP-eBGP peering between the two RRs of different AS'es in order to exchange VPNv4 routes.
 3. To be able to have an eBGP session between RR's, Remote Route-reflector Loopback addresses are required to be known in the local AS and vice-versa. This is accomplished using the mutual redistribution between OSPF and bgp on the two ASBRs. The redistribution is controlled using the route-maps and only permits the
 1. Local Route-reflectors Loopback address to be redistributed from local OSPF to BGP.
 2. Remote Route-reflectors Loopback address to be redistributed from bgp to local OSPF.
 4. Next-hop attribute should not be changed when RR reflects the VPNv4 route from iBGP peering to the remote RR over an eBGP peering. This is accomplished using the configuration "attribute-unchanged next-hop" for the eBGP neighbor.
 5. Next-hop attribute should be changed when ASBR advertises the remote PE's Loopback address as LU route to the RR. This is accomplished using the configuration "next-hop self" for the iBGP RR neighbor
- (1) and (5) enables an end to end LSP between the two PE's which needs to run the L3VPN service and (2), (3) and (4) enables the RR's to form BGP neighborhood with each other and successfully exchange the VPNv4 Routes.

Topology

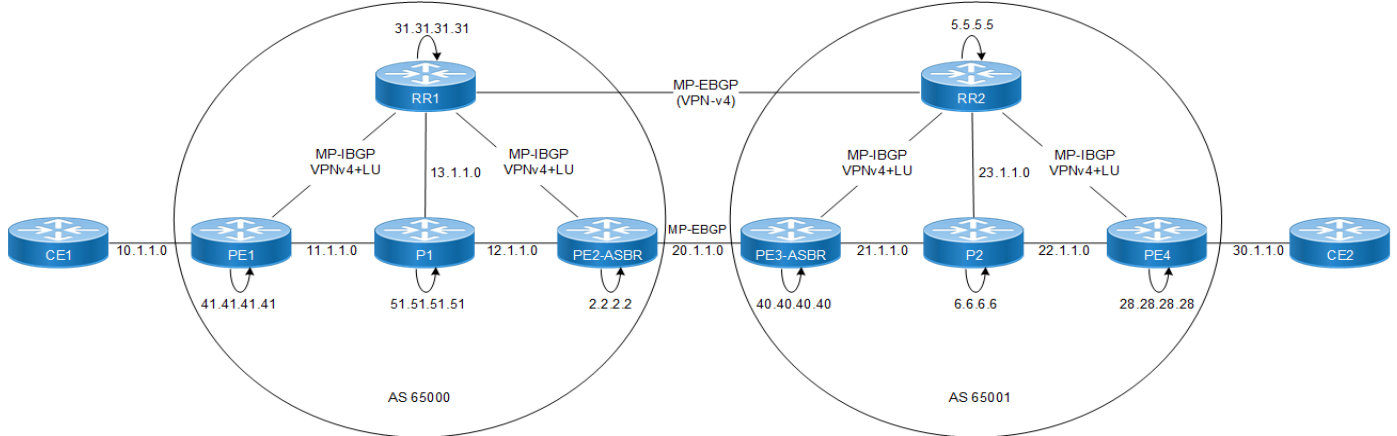


Figure 14-4: InterAS-VPN Option-C with RR

PE1

PE1(#configure terminal	Enter configure mode.
PE1(config-router)#interface lo	Enter interface mode.
PE1(config-if)# ip address 41.41.41.41/32 secondary	Assign the IPv4 address.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#ip vrf vrf1	Create a new VRF named vrf1.
PE1(config-vrf)# rd 1:1	Assign the route distinguisher (RD) value as 1:1.
PE1(config-vrf)# route-target both 1:1	Configure import and export route-target values
PE1(config-vrf)#exit	Exit VRF mode.
PE1(config-if)#interface xe23	Enter interface mode.
PE1(config-if)# ip vrf forwarding vrf1	Bind the interface connected to the CE router with VRF vrf1.
PE1(config-if)# ip address 10.1.1.2/24	Assign the IPv4 address.
PE1(config-if)#exit	Exit interface mode.
PE1(config-if)#interface xe15	Enter interface mode.
PE1(config-if)# ip address 11.1.1.2/24	Assign the IPv4 address.
PE1(config-if)#exit	Exit interface mode.
PE1(config-if)#router ospf 1	Enter router OSPF mode.
PE1(config-router)# ospf router-id 41.41.41.41	Configure OSPF router id same as loopback ip address.
PE1(config-router)# network 11.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE1(config-router)# network 41.41.41.41/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE1(config)#router ldp	Enter router LDP mode.
PE1(config-router)#router-id 41.41.41.41	Set the router ID to IP address 41.41.41.41
PE1(config-router)#transport-address ipv4 41.41.41.41	Configure LDP transport address same as loopback address.

PE1(config-router)#exit	Exit LDP mode.
PE1(config-if)#interface xe15	Enter interface mode.
PE1(config-if)# label-switching	Enable label switching in interface.
PE1(config-if)# enable-ldp ipv4	Enable LDP in interface.
PE1(config-if)#exit	Exit interface mode.
PE1(config-router)#router bgp 65000	Enter BGP router mode.
PE1(config-router)# bgp router-id 41.41.41.41	Configure BGP router-id.
PE1(config-router)# no bgp default ipv4-unicast	Configure BGP peer to have no ipv4 unicast capability exchange by default.
PE1(config-router)# neighbor 31.31.31.31 remote-as 65000	Configure neighbor with remote AS.
PE1(config-router)# neighbor 31.31.31.31 update-source lo	Update the loopback as the source of BGP session.
PE1(config-router)# allocate-label all	Allocate the label for all advertised networks.
PE1(config-router)# address-family ipv4 labeled-unicast	Enter the IPv4 labeled-unicast address family
PE1(config-router-af)# neighbor 31.31.31.31 activate	Activate the neighbor under the address-family.
PE1(config-router-af)# exit-address-family	Exit IPv4 labeled-unicast Address Family mode.
PE1(config-router)# address-family vpnv4 unicast	Enter vpnv4 unicast address-family mode.
PE1(config-router-af)# neighbor 31.31.31.31 activate	Activate the neighbor under vpnv4 unicast address-family.
PE1(config-router-af)# exit-address-family	Exit vpnv4 unicast address-family.
PE1(config-router)# address-family ipv4 vrf vrf1	Enter ipv4 VRF address-family mode.
PE1(config-router-af)# redistribute connected	Redistribute connected networks under VRF address-family.
PE1(config-router-af)# exit-address-family	Exit ipv4 VRF address-family.
PE1(config-router)#exit	Exit the router mode.
PE1(config)#commit	Commit candidate configuration to be running configuration.
PE1(config)#exit	Exit the config mode.

P1

P1(config)#interface lo	Enter interface mode.
P1(config-if)# ip address 51.51.51.51/32 secondary	Assign the secondary IPv4 address on loopback interface.
P1(config-if)#interface xe15	Enter interface mode.
P1(config-if)# ip address 11.1.1.31/24	Assign the IPv4 address.
P1(config-if)#interface xe21	Enter interface mode.
P1(config-if)# ip address 12.1.1.31/24	Assign the IPv4 address.
P1(config-if)#interface xe22	Enter interface mode.
P1(config-if)# ip address 13.1.1.1/24	Assign the IPv4 address.

P1(config-if)#router ospf 1	Enter router OSPF mode.
P1(config-router)# ospf router-id 51.51.51.51	Configure OSPF router-id (optional).
P1(config-router)# network 11.1.1.0/24 area 0.0.0.0	Enable networks for OSPF protocol.
P1(config-router)# network 12.1.1.0/24 area 0.0.0.0	Enable networks for OSPF protocol.
P1(config-router)# network 13.1.1.0/24 area 0.0.0.0	Enable networks for OSPF protocol.
P1(config-router)# network 51.51.51.51/32 area 0.0.0.0	Enable networks for OSPF protocol.
P1(config-router)#router ldp	Enter router LDP mode. This is required to enable LDP globally on the router.
P1(config-router)#router-id 51.51.51.51	Set the router ID to IP address 51.51.51.51
P1(config-router)#transport-address ipv4 51.51.51.51	Configure LDP transport address same as loopback address.
P1(config-router)#interface xe15	Enter interface configuration mode.
P1(config-if)# label-switching	Configure label-switching on the interface.
P1(config-if)# enable-ldp ipv4	Enable LDP on the interface.
P1(config-if)#interface xe21	Enter interface configuration mode.
P1(config-if)# label-switching	Configure label-switching on the interface.
P1(config-if)# enable-ldp ipv4	Enable LDP on the interface.
P1(config-if)#exit	Exit interface mode.
P1(config)#commit	Commit candidate configuration to the running configuration.
P1(config)#exit	Exit the config mode.

RR1

#configure terminal	Enter configure mode.
RR1(config)#interface lo	Enter interface mode.
RR1(config-if)# ip address 31.31.31.31/32 secondary	Assign the IPv4 address.
RR1(config-if)#interface xe22	Exit interface mode.
RR1(config-if)# ip address 13.1.1.2/24	Assign the IPv4 address.
RR1(config-if)#router ospf 1	Enter router OSPF mode.
RR1(config-router)# ospf router-id 31.31.31.31	Configure OSPF router-id explicitly (optional).
RR1(config-router)# network 13.1.1.0/24 area 0.0.0.0	Enable networks for OSPF protocol under area 0.
RR1(config-router)# network 31.31.31.31/32 area 0.0.0.0	Enable networks for OSPF protocol under area 0.
RR1(config-router)#router bgp 65000	Enter BGP router mode.
RR1(config-router)# bgp router-id 31.31.31.31	Configure BGP router-id.
RR1(config-router)# no bgp default ipv4-unicast	Disable default ipv4-unicast capability exchange with BGP neighbors.

RR1(config-router)# no bgp inbound-route-filter	Disable inbound route-filtering for bgp VPNV4 routes. This is required for Route-reflectors.
RR1(config-router)# neighbor 2.2.2.2 remote-as 65000	Configure PE2-ASBR as iBGP neighbor.
RR1(config-router)# neighbor 2.2.2.2 update-source lo	Configure BGP speaker to use loopback address as source for BGP session.
RR1(config-router)# neighbor 5.5.5.5 remote-as 65001	Configure RR2 as an eBGP neighbor.
RR1(config-router)# neighbor 5.5.5.5 ebgp-multihop	Enable multihop on eBGP session.
RR1(config-router)# neighbor 5.5.5.5 update-source lo	Configure BGP speaker to use loopback address as source for this BGP session.
RR1(config-router)# neighbor 41.41.41.41 remote-as 65000	Configure PE1 as an iBGP neighbor.
RR1(config-router)# neighbor 41.41.41.41 update-source lo	Configure BGP speaker to use loopback address as source for this BGP session.
RR1(config-router)# allocate-label all	Configure this peer to allocate label for all advertised networks.
RR1(config-router)# address-family ipv4 labeled-unicast	Enter ipv4 labeled-unicast address-family.
RR1(config-router-af)# neighbor 2.2.2.2 activate	Activate PE2-ASBR for this AFI/SAFI.
RR1(config-router-af)# neighbor 2.2.2.2 route-reflector-client	Configure PE2-ASBR as Route-reflector client.
RR1(config-router-af)# neighbor 41.41.41.41 activate	Activate PE1 for this AFI/SAFI.
RR1(config-router-af)# neighbor 41.41.41.41 route-reflector-client	Configure PE1 as Route-reflector client.
RR1(config-router-af)# exit-address-family	Exit ipv4 labeled-unicast address-family.
RR1(config-router)# address-family vpnv4 unicast	Enter vpnv4 unicast address-family.
RR1(config-router-af)# neighbor 5.5.5.5 allow-ebgp-vpn	Allow eBGP VPN route exchange for the RR2 eBGP neighbor.
RR1(config-router-af)# neighbor 5.5.5.5 activate	Activate the RR2 eBGP neighbor.
RR1(config-router-af)# neighbor 5.5.5.5 attribute-unchanged next-hop	Configure next-hop unchanged for this eBGP neighbor for all vpnv4 NLRIs to keep original next-hop while advertising to this eBGP neighbor.
RR1(config-router-af)# neighbor 41.41.41.41 activate	Activate PE1 iBGP neighbor.
RR1(config-router-af)# neighbor 41.41.41.41 route-reflector-client	Configure PE1 as Route-reflector client for this AFI/SAFI.
RR1(config-router-af)# exit-address-family	Exit Address-family mode.
RR1(config-router)#exit	Exit the router mode.
RR1(config)#commit	Commit candidate configuration to be running configuration.
RR1(config)#exit	Exit the config mode.

PE2-ASBR

PE2-ASBR#configure terminal	Enter configure mode.
PE2-ASBR(config)#interface lo	Enter interface mode.
PE2-ASBR(config-if)# ip address 2.2.2.2/32 secondary	Assign a secondary IPv4 address to the loopback interface.
PE2-ASBR(config-if)#interface xe20	Enter interface mode.
PE2-ASBR(config-if)# ip address 12.1.1.2/24	Assign an IPv4 address to the interface.
PE2-ASBR(config-if)#interface xe5	Enter interface mode.
PE2-ASBR(config-if)# ip address 20.1.1.2/24	Assign an IPv4 address to the interface.
PE2-ASBR(config-if)#ip access-list standard RR1_LO	Create an IP standard access list to permit RR1s loopback address. This is required to redistribute RR1 Lo from OSPF to BGP.
PE2-ASBR(config-ip-acl-std)# permit host 31.31.31.31	Permit RR1 loopback address.
PE2-ASBR(config-ip-acl-std)#ip access-list standard RR2_LO	Create an IP standard access list to permit RR2 Lo address. This is required to redistribute RR2 Lo from BGP to OSPF.
PE2-ASBR(config-ip-acl-std)# permit host 5.5.5.5	Permit RR2s Loopback address.
PE2-ASBR(config-ip-acl-std)#route-map RR1_LO permit 10	Create a Route-map to allow RR1-LO address . This is required when redistributing from OSPF to BGP.
PE2-ASBR(config-route-map)# match ip address RR1_LO	match the RR1_LO access list.
PE2-ASBR(config-route-map)#route-map RR2_LO permit 10	Create a Route-map to allow RR2-LO address . This is required when redistributing from BGP to OSPF.
PE2-ASBR(config-route-map)# match ip address RR2_LO	match the RR2_LO access list.
PE2-ASBR(config-route-map)#router ospf 1	Enter router OSPF mode.
PE2-ASBR(config-router)# ospf router-id 2.2.2.2	Configure OSPF router-id explicitly (optional).
PE2-ASBR(config-router)# redistribute bgp route-map RR2_LO	Redistribute RR2's Lo from BGP to OSPF. This is required for eBGP session between RR1 and RR2.
PE2-ASBR(config-router)# network 2.2.2.2/32 area 0.0.0.0	Enable OSPF networks/links in area 0.
PE2-ASBR(config-router)# network 12.1.1.0/24 area 0.0.0.0	Enable OSPF networks/links in area 0.
PE2-ASBR(config-router)#router ldp	Enter Router ldp mode. This is required to enable ldp globally on the router.
PE2-ASBR(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2
PE2-ASBR(config-router)#transport-address ipv4 2.2.2.2	Configure LDP transport address same as loopback address.
PE2-ASBR(config-router)#interface xe20	Enter interface mode.
PE2-ASBR(config-if)# label-switching	Configure label-switching to enable MPLS forwarding on this interface.
PE2-ASBR(config-if)# enable-ldp ipv4	Enable LDP on this interface.
PE2-ASBR(config-if)#interface xe5	Enter interface mode.
PE2-ASBR(config-if)# label-switching	Configure label-switching to enable MPLS forwarding on this interface.

PE2-ASBR(config-if)#router bgp 65000	Enter router BGP configuration mode.
PE2-ASBR(config-router)# bgp router-id 2.2.2.2	Configure BGP router-id.
PE2-ASBR(config-router)# no bgp default ipv4-unicast	Configure BGP to disable default exchange of ipv4 unicast AFI/SAFI capability.
PE2-ASBR (config-router)# address-family ipv4 unicast	Enter address-family ipv4 unicast mode
PE2-ASBR(config-router-af)# redistribute ospf route-map RR1_LO	Redistribute RR1 Lo from OSPF to BGP. This is required for eBGP session between RR1 and RR2.
PE2-ASBR(config-router-af)#exit	Exit address-family mode
PE2-ASBR(config-router)# neighbor 20.1.1.40 remote-as 65001	Configure PE3-ASBR as eBGP neighbor.
PE2-ASBR(config-router)# neighbor 20.1.1.40 activate	Activate PE3-ASBR neighbor for IPv4 unicast AFI/SAFI. This is required to exchange the redistributed RR1 Lo prefix to PE3-ASBR eBGP peer.
PE2-ASBR(config-router)# neighbor 31.31.31.31 remote-as 65000	Configure RR1 as an iBGP neighbor.
PE2-ASBR(config-router)# neighbor 31.31.31.31 update-source lo	Update the source of the iBGP session to loopback address.
PE2-ASBR(config-router)# allocate-label all	Configure this command to allocate label for all advertised networks.
PE2-ASBR(config-router)# address-family ipv4 labeled-unicast	Enter ipv4 labeled-unicast AFI/SAFI.
PE2-ASBR(config-router-af)# neighbor 20.1.1.40 activate	Activate PE3-ASBR neighbor for IPv4 labeled-unicast.
PE2-ASBR(config-router-af)# neighbor 31.31.31.31 activate	Activate RR1 neighbor for IPv4 labeled-unicast.
PE2-ASBR(config-router-af)# neighbor 31.31.31.31 next-hop-self	Configure next-hop-self for the RR1 neighbor.
PE2-ASBR(config-router-af)# exit-address-family	Exit this address-family.
PE2-ASBR(config-router)#exit	Exit the router mode.
PE2-ASBR (config)#commit	Commit candidate configuration to be running configuration.
PE2-ASBR(config)#exit	Exit the config mode.

PE3-ASBR

#configure terminal	Enter configure mode.
PE3-ASBR(config)#interface lo	Enter interface mode.
PE3-ASBR(config-if)# ip address 40.40.40.40/32 secondary	Assign a secondary IPv4 address to the loopback interface.
PE3-ASBR(config-if)#interface xe5	Enter interface mode.
PE3-ASBR(config-if)# ip address 20.1.1.40/24	Assign an IPv4 address to the interface.
PE3-ASBR(config-if)#interface xe1	Enter interface mode.
PE3-ASBR(config-if)# ip address 21.1.1.40/24	Assign an IPv4 address to the interface.
PE3-ASBR(config-if)#ip access-list standard RR1_LO	Create an IP standard access list to permit RR1s loopback address. This is required to redistribute RR1 Lo from BGP to OSPF.

PE3-ASBR(config-ip-acl-std)# permit host 31.31.31.31	Permit RR1 loopback address.
PE3-ASBR(config-ip-acl-std)#ip access-list standard RR2_LO	Create an IP standard access list to permit RR2 Lo address. This is required to redistribute RR2 Lo from OSPF to BGP.
PE3-ASBR(config-ip-acl-std)# permit host 5.5.5.5	Permit RR2s Loopback address.
PE3-ASBR(config-ip-acl-std)#route-map RR1_LO permit 10	Create a Route-map to allow RR1-LO address . This is required when redistributing from BGP to OSPF.
PE3-ASBR(config-route-map)# match ip address RR1_LO	match the RR1_LO access list.
PE3-ASBR(config-route-map)#route-map RR2_LO permit 10	Create a Route-map to allow RR2-LO address . This is required when redistributing from OSPF to BGP.
PE3-ASBR(config-route-map)# match ip address RR2_LO	match the RR2_LO access list.
PE3-ASBR(config-route-map)#router ospf 1	Enter router OSPF mode.
PE3-ASBR(config-router)# ospf router-id 40.40.40.40	Configure OSPF router-id explicitly (optional).
PE3-ASBR(config-router)# redistribute bgp route-map RR1_LO	Redistribute RR2's Lo from OSPF to BGP. This is required for eBGP session between RR1 and RR2.
PE3-ASBR(config-router)# network 21.1.1.0/24 area 0.0.0.0	Enable OSPF networks/links in area 0.
PE3-ASBR(config-router)# network 40.40.40.40/32 area 0.0.0.0	Enable OSPF networks/links in area 0.
PE3-ASBR(config-router)#router ldp	Enter Router LDP mode. This is required to enable LDP globally on the router.
PE3-ASBR(config-router)#router-id 40.40.40.40	Set the router ID to IP address 40.40.40.40
PE3-ASBR(config-router)#transport-address ipv4 40.40.40.40	Configure LDP transport address same as loopback address
PE3-ASBR(config-router)#interface xe5	Enter interface mode.
PE3-ASBR(config-if)# label-switching	Configure label-switching to enable MPLS forwarding on this interface.
PE3-ASBR(config-if)#interface xe1	Enter interface mode.
PE3-ASBR(config-if)# label-switching	Configure label-switching to enable MPLS forwarding on this interface.
PE3-ASBR(config-if)# enable-ldp ipv4	Enable LDP on this interface.
PE3-ASBR(config-if)#router bgp 65001	Enter router BGP configuration mode.
PE3-ASBR(config-router)# bgp router-id 40.40.40.40	Configure BGP router-id.
PE3-ASBR(config-router)# no bgp default ipv4-unicast	Configure BGP to disable default exchange of ipv4 unicast AFI/SAFI capability.
PE3-ASBR(config-router)# redistribute ospf route-map RR2_LO	Redistribute RR2 Lo from OSPF to BGP. This is required for eBGP session between RR1 and RR2.
PE3-ASBR(config-router)# neighbor 5.5.5.5 remote-as 65001	Configure RR2 as eBGP neighbor.
PE3-ASBR(config-router)# neighbor 5.5.5.5 update-source lo	Update the source of the iBGP session to loopback address.
PE3-ASBR(config-router)# neighbor 20.1.1.2 remote-as 65000	Configure PE2-ASBR as an eBGP neighbor.

PE3-ASBR(config-router)# neighbor 20.1.1.2 activate	Activate PE2-ASBR neighbor for IPv4 unicast AFI/SAFI. This is required to exchange the redistributed RR1 Lo prefix to PE2-ASBR eBGP peer.
PE3-ASBR(config-router)# allocate-label all	Configure this command to allocate label for all advertised networks.
PE3-ASBR(config-router)# address-family ipv4 labeled-unicast	Enter ipv4 labeled-unicast AFI/SAFI.
PE3-ASBR(config-router-af)# neighbor 5.5.5.5 activate	Activate RR1 neighbor for IPv4 labeled-unicast.
PE3-ASBR(config-router-af)# neighbor 5.5.5.5 next-hop-self	Configure next-hop-self for the RR2 neighbor.
PE3-ASBR(config-router-af)# neighbor 20.1.1.2 activate	Activate PE2-ASBR neighbor for IPv4 labeled-unicast.
PE3-ASBR(config-router-af)# ex-it-address-family	Exit this address-family.
PE3-ASBR(config-router)#exit	Exit the router mode.
PE3-ASBR(config)#commit	Commit candidate configuration to be running configuration.
PE3-ASBR(config)#exit	Exit the config mode.

RR2

#configure terminal	Enter configure mode.
RR2(config)#interface lo	Enter interface mode.
RR2(config-if)# ip address 5.5.5.5/32 secondary	Assign the IPv4 address.
RR2(config-if)#interface xe22	Enter interface mode.
RR2(config-if)# ip address 23.1.1.2/24	Assign the IPv4 address.
RR2(config-if)#router ospf 1	Enter router OSPF mode.
RR2(config-router)# ospf router-id 5.5.5.5	Configure OSPF router-id explicitly (optional).
RR2(config-router)# network 5.5.5.5/32 area 0.0.0.0	Enable networks for OSPF protocol under area 0.
RR2(config-router)# network 23.1.1.0/24 area 0.0.0.0	Enable networks for OSPF protocol under area 0.
RR2(config-router)#router bgp 65001	Enter BGP router mode.
RR2(config-router)# bgp router-id 5.5.5.5	Configure BGP router-id.
RR2(config-router)# no bgp default ipv4-unicast	Disable default ipv4-unicast capability exchange with BGP neighbors.
RR2(config-router)# no bgp inbound-route-filter	Disable inbound route-filtering for bgp VPNV4 routes. This is required for Route-reflectors.
RR2(config-router)# neighbor 28.28.28.28 remote-as 65001	Configure PE2-ASBR as iBGP neighbor.
RR2(config-router)# neighbor 28.28.28.28 update-source lo	Configure BGP speaker to use loopback address as source for BGP session.
RR2(config-router)# neighbor 31.31.31.31 remote-as 65000	Configure RR2 as an eBGP neighbor.
RR2(config-router)# neighbor 31.31.31.31 ebgp-multihop	Enable multihop on eBGP session.

RR2(config-router)# neighbor 31.31.31.31 update-source lo	Configure BGP speaker to use loopback address as source for this BGP session.
RR2(config-router)# neighbor 40.40.40.40 remote-as 65001	Configure PE1 as an iBGP neighbor.
RR2(config-router)# neighbor 40.40.40.40 update-source lo	Configure BGP speaker to use loopback address as source for this BGP session.
RR2(config-router)# allocate-label all	Configure this peer to allocate label for all advertised networks.
RR2(config-router)# address-family ipv4 labeled-unicast	Enter ipv4 labeled-unicast address-family.
RR2(config-router-af)# neighbor 28.28.28.28 activate	Activate PE2-ASBR for this AFI/SAFI.
RR2(config-router-af)# neighbor 28.28.28.28 route-reflector-client	Configure PE2-ASBR as Route-reflector client.
RR2(config-router-af)# neighbor 40.40.40.40 activate	Activate PE1 for this AFI/SAFI.
RR2(config-router-af)# neighbor 40.40.40.40 route-reflector-client	Configure PE1 as Route-reflector client.
RR2(config-router-af)# exit-address-family	Exit ipv4 labeled-unicast address-family.
RR2(config-router)# address-family vpnv4 unicast	Enter vpnv4 unicast address-family.
RR2(config-router-af)# neighbor 28.28.28.28 activate	Allow eBGP vpn route exchange for the RR2 eBGP neighbor.
RR2(config-router-af)# neighbor 28.28.28.28 route-reflector-client	Activate the RR2 eBGP neighbor.
RR2(config-router-af)# neighbor 31.31.31.31 allow-ebgp-vpn	Configure next-hop unchanged for this eBGP neighbor for all vpnv4 NLRI to keep original next-hop while advertising to this eBGP neighbor.
RR2(config-router-af)# neighbor 31.31.31.31 activate	Activate PE1 iBGP neighbor.
RR2(config-router-af)# neighbor 31.31.31.31 attribute-unchanged next-hop	Configure PE1 as Route-reflector client for this AFI/SAFI.
RR2(config-router-af)# exit-address-family	Exit Address-family mode.
RR2(config-router)#exit	Exit the router mode.
RR2(config)#commit	Commit candidate configuration to be running configuration.
RR2(config)#exit	Exit the config mode.

P2

P2(config)#interface lo	Enter interface mode.
P2(config-if)# ip address 6.6.6.6/32 secondary	Assign the secondary IPv4 address on loopback interface.
P2(config-if)#interface xe22	Enter interface mode.
P2(config-if)# ip address 23.1.1.1/24	Assign the IPv4 address.
P2(config-if)#interface xe0	Enter interface mode.
P2(config-if)# ip address 21.1.1.5/24	Assign the IPv4 address.
P2(config-if)#interface xe11	Enter interface mode.

P2(config-if)# ip address 22.1.1.5/24	Assign the IPv4 address.
P2(config-if)#router ospf 1	Enter router OSPF mode.
P2(config-router)# ospf router-id 6.6.6.6	Configure OSPF router-id (optional).
P2(config-router)# network 6.6.6.6/32 area 0.0.0.0	Enable networks for OSPF protocol.
P2(config-router)# network 21.1.1.0/24 area 0.0.0.0	Enable networks for OSPF protocol.
P2(config-router)# network 22.1.1.0/24 area 0.0.0.0	Enable networks for OSPF protocol.
P2(config-router)# network 23.1.1.0/24 area 0.0.0.0	Enable networks for OSPF protocol.
P2(config-router)#router ldp	Enter router ldp mode. This is required to enable LDP globally on the router.
P2(config-router)#router-id 6.6.6.6	Set the router ID to IP address 6.6.6.6
P2(config-router)#transport-address ipv4 6.6.6.6	Configure LDP transport address same as loopback address.
P2(config-router)#interface xe0	Enter interface configuration mode.
P2(config-if)# label-switching	Configure label-switching on the interface.
P2(config-if)# enable-ldp ipv4	Enable LDP on the interface.
P2(config-if)#interface xe11	Enter interface configuration mode.
P2(config-if)# label-switching	Configure label-switching on the interface.
P2(config-if)# enable-ldp ipv4	Enable LDP on the interface.
P2(config-if)#exit	Exit interface mode.
P2(config)#commit	Commit candidate configuration to be running configuration.
P2(config)#exit	Exit the config mode.

PE4

#configure terminal	Enter configure mode.
PE4(config)#interface lo	Enter interface mode.
PE4(config-if)# ip address 28.28.28.28/32 secondary	Assign the secondary IPv4 address on the loopback interface.
PE4(config-if)#ip vrf vrf1	Create a new VRF named vrf1.
PE4(config-vrf)# rd 1:1	Assign the route distinguisher (RD) value as 1:1.
PE4(config-vrf)# route-target both 1:1	Configure import and export route-target values.
PE4(config-vrf)#interface xe21	Enter interface mode.
PE4(config-if)# ip vrf forwarding vrf1	Bind the interface connected to the CE router with VRF vrf1.
PE4(config-if)# ip address 30.1.1.1/24	Assign the IPv4 address.
PE4(config-if)#interface xe11	Enter interface mode.
PE4(config-if)# ip address 22.1.1.28/24	Assign the IPv4 address.
PE4(config-if)#router ospf 1	Enter router OSPF mode.
PE4(config-router)# ospf router-id 28.28.28.28	Configure OSPF router id same as loopback ip address.
PE4(config-router)# network 22.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.

PE4(config-router)# network 28.28.28.28/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE4(config-router)#router ldp	Enter router LDP mode.
PE4(config-router)#router-id 28.28.28.28	Set the router ID to IP address 28.28.28.28
PE4(config-router)#transport-address ipv4 28.28.28.28	Configure LDP transport address same as loopback address.
PE4(config-router)#interface xel1	Enter interface mode.
PE4(config-if)# label-switching	Enable label switching in interface.
PE4(config-if)# enable-ldp ipv4	Enable LDP in interface.
PE4(config-if)#router bgp 65001	Enter BGP router mode.
PE4(config-router)# bgp router-id 28.28.28.28	Configure BGP router-id.
PE4(config-router)# no bgp default ipv4- unicast	Configure BGP peer to have no ipv4 unicast capability exchange by default.
PE4(config-router)# address-family ipv4 unicast	Enter the IPv4 unicast address family.
PE4(config-router-af)# network 28.28.28.28/ 32	advertise the network of this BGP speaker.
PE4(config-router-af)# exit-address-family	Exit address family mode.
PE4(config-router)# neighbor 5.5.5.5 remote- as 65001	configure neighbor with remote AS.
PE4(config-router)# neighbor 5.5.5.5 update- source lo	Update the loopback as the source of BGP session.
PE4(config-router)# allocate-label all	Allocate the label for all advertised networks.
PE4(config-router)# address-family ipv4 labeled-unicast	Enter the IPv4 labeled-unicast address family.
PE4(config-router-af)# neighbor 5.5.5.5 activate	Activate the neighbor under the address-family.
PE4(config-router-af)# exit-address-family	Exit IPv4 labeled-unicast Address Family mode.
PE4(config-router)# address-family vpnv4 unicast	Enter vpnv4 unicast address-family mode.
PE4(config-router-af)# neighbor 5.5.5.5 activate	Activate the neighbor under vpnv4 unicast address-family.
PE4(config-router-af)# exit-address-family	Exit vpnv4 unicast address-family.
PE4(config-router)# address-family ipv4 vrf vrf1	Enter ipv4 VRF address-family mode.
PE4(config-router-af)# redistribute connected	Redistribute connected networks under VRF address-family.
PE4(config-router-af)# exit-address-family	Exit ipv4 VRF address-family.
PE4(config-router)#exit	Exit the router mode.
PE4(config)#commit	Commit candidate configuration to be running configuration.
PE4(config)#exit	Exit the config mode.

Validation

PE1

```
PE1#show ip bgp labeled-unicast summary
BGP router identifier 41.41.41.41, local AS number 65000
BGP table version is 5
2 BGP AS-PATH entries
0 BGP community entries
```

Neighbor	Down	State/PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
31.31.31.31			4	65000	5920	5932	5	0	0	
1d15h58m			3							

Total number of neighbors 1

Total number of Established sessions 1

```
PE1#show ip bgp labeled-unicast
```

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, S - stale

Network	Next Hop	In Label	Out Label
*>i 5.5.5.5/32	2.2.2.2	24963	24965
*>i 28.28.28.28/32	2.2.2.2	24965	24964
*>i 31.31.31.31/32	2.2.2.2	24967	24961
*> 41.41.41.41/32	0.0.0.0	24961	-

```
PE1#show mpls forwarding-table
```

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	ELC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-
Label	Out-Intf		Nexthop				
L>	2.2.2.2/32		4	0	Yes	LSP_DEFAULT	24321
xe15	No	11.1.1.31					
L>	5.5.5.5/32		6	0	Yes	LSP_DEFAULT	24324
xe15	No	11.1.1.31					
B	5.5.5.5/32		7	0	Yes	LSP_DEFAULT	24965
-	No	2.2.2.2					
L>	12.1.1.0/24		2	0	Yes	LSP_DEFAULT	3
xe15	No	11.1.1.31					
L>	13.1.1.0/24		3	0	Yes	LSP_DEFAULT	3
e15	No	11.1.1.31					
B>	28.28.28.28/32		9	0	Yes	LSP_DEFAULT	24964
-	No	2.2.2.2					
L>	31.31.31.31/32		5	0	Yes	LSP_DEFAULT	24322
xe15	No	11.1.1.31					
B	31.31.31.31/32		11	0	Yes	LSP_DEFAULT	24961
-	No	2.2.2.2					
L>	51.51.51.51/32		1	0	Yes	LSP_DEFAULT	3
xe15	No	11.1.1.31					

```
PE1#show ip bgp vpnv4 all summary
```


BGP router identifier 41.41.41.41, local AS number 65000
 BGP table version is 2
 2 BGP AS-PATH entries
 0 BGP community entries

Neighbor	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
Down State/PfxRcd								
31.31.31.31	4	65000	5928	5940	2	0	0	
1d16h01m	1							

Total number of neighbors 1

Total number of Established sessions 1

PE1#show ip bgp vpnv4 all
 Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, l - labeled
 S Stale
 Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (Default for VRF vrfl)					
*> 1 10.1.1.0/24	0.0.0.0	0	100	32768	?
*>il 30.1.1.0/24	28.28.28.28	0	100	0	
65001 ?					
Announced routes count = 1					
Accepted routes count = 1					
Route Distinguisher: 1:1					
*>il 30.1.1.0/24	28.28.28.28	0	100	0	
65001 ?					
Announced routes count = 0					
Accepted routes count = 1					

PE1#show ip route vrf vrfl database
 Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
 O - OSPF, IA - OSPF inter area
 N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
 E1 - OSPF external type 1, E2 - OSPF external type 2
 i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
 ia - IS-IS inter area, E - EVPN,
 v - vrf leaked
 > - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrfl"
 C *> 10.1.1.0/24 is directly connected, xe23, 1d15h59m
 B *> 30.1.1.0/24 [200/0] via 28.28.28.28, 1d15h47m

Gateway of last resort is not set

P1

P1#show mpls ilm-table
 Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, S - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS_SR, k - SR_CLI
 P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-
Intf/VRF	Nextthop		LSP-Type			
L> 2.2.2.2/32	2	24321	3	N/A	xe21	
12.1.1.2	LSP_DEFAULT					
L> 41.41.41.41/32	1	24320	3	N/A	xe15	
11.1.1.2	LSP_DEFAULT					
L> 31.31.31.31/32	4	24323	Nolabel	N/A	N/A	
127.0.0.1	LSP_DEFAULT					
L> 31.31.31.31/32	3	24322	Nolabel	N/A	N/A	
127.0.0.1	LSP_DEFAULT					
L> 5.5.5.5/32	5	24324	Nolabel	N/A	N/A	
127.0.0.1	LSP_DEFAULT					

RR1

```
RR1#show ip route ospf
IP Route Table for VRF "default"
O          2.2.2.2/32 [110/3] via 13.1.1.1, xe22, 1d16h37m
O E2       5.5.5.5/32 [110/1] via 13.1.1.1, xe22, 1d16h35m
O          11.1.1.0/24 [110/2] via 13.1.1.1, xe22, 1d16h37m
O          12.1.1.0/24 [110/2] via 13.1.1.1, xe22, 1d16h37m
O          41.41.41.41/32 [110/3] via 13.1.1.1, xe22, 1d16h37m
O          51.51.51.51/32 [110/2] via 13.1.1.1, xe22, 1d16h37m
```

Gateway of last resort is not set

```
RR1#sho ip bgp labeled-unicast summary
BGP router identifier 31.31.31.31, local AS number 65000
BGP table version is 9
2 BGP AS-PATH entries
0 BGP community entries
```

Neighbor	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
Down State/PfxRcd								
2.2.2.2	4	65000	7514	7654	9	0	0	
1d16h11m	3							
41.41.41.41	4	65000	5961	5951	9	0	0	
1d16h11m	1							

Total number of neighbors 2

Total number of Established sessions 2

```
RR1#show ip bgp labeled-unicast
```

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, S - stale

Network	Next Hop	In Label	Out Label
*>i 5.5.5.5/32	2.2.2.2	24320	24965
*>i 28.28.28.28/32	2.2.2.2	24323	24964
*>i 31.31.31.31/32	2.2.2.2	24327	24961
*>i 41.41.41.41/32	41.41.41.41	24326	24961

```
RR1#show ip bgp vpnv4 all summary
BGP router identifier 31.31.31.31, local AS number 65000
BGP table version is 3
2 BGP AS-PATH entries
0 BGP community entries
```

Neighbor Down State/PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
5.5.5.5	4	65001	5729	5725	3	0	0	
1d15h56m	1							
41.41.41.41	4	65000	5962	5953	3	0	0	
1d16h12m	1							

Total number of neighbors 2

Total number of Established sessions 2

RR1#show ip bgp vpnv4 all

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, l - labeled

S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1					
*>i 10.1.1.0/24	41.41.41.41	0	100	0	?
*> 30.1.1.0/24	28.28.28.28	0	100	0	
65001 ?					
Announced routes count = 0					
Accepted routes count = 2					

PE2-ASBR

PE2-ASBR#show ip bgp labeled-unicast summary

BGP router identifier 2.2.2.2, local AS number 65000

BGP table version is 6

2 BGP AS-PATH entries

0 BGP community entries

Neighbor Down State/PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
20.1.1.40	4	65001	5884	5976	6	0	0	
1d16h37m	2							
31.31.31.31	4	65000	5790	5794	6	0	0	
1d16h15m	1							

Total number of neighbors 2

Total number of Established sessions 2

PE2-ASBR#show ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, S - stale

Network	Next Hop	In Label	Out Label
*> 5.5.5.5/32	20.1.1.40	24965	24965
*> 28.28.28.28/32	20.1.1.40	24964	24962
*> 31.31.31.31/32	12.1.1.31	24961	-
*>i 41.41.41.41/32	41.41.41.41	24967	24961

PE2-ASBR#sho mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM

K - CLI ILM, T - MPLS-TP, S - Stitched ILM

S - SNMP, L - LDP, R - RSVP, C - CRLDP

B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-
Intf/VRF	Nextthop		LSP-Type			
B>	5.5.5.5/32	6	24965	24965	N/A	N/A
20.1.1.40			LSP_DEFAULT			
B>	28.28.28.28/32	5	24964	24962	N/A	N/A
20.1.1.40			LSP_DEFAULT			
B>	31.31.31.31/32	2	24961	Nolabel	N/A	N/A
127.0.0.1			LSP_DEFAULT			
B>	41.41.41.41/32	8	24967	24961	N/A	N/A
41.41.41.41			LSP_DEFAULT			

PE2-ASBR#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-
Label	Out-Intf	ELC	Nextthop			
B>	5.5.5.5/32	8	0	Yes	LSP_DEFAULT	24965
xe5	No	20.1.1.40				
L>	11.1.1.0/24	1	0	Yes	LSP_DEFAULT	3
xe20	No	12.1.1.31				
L>	13.1.1.0/24	2	0	Yes	LSP_DEFAULT	3
xe20	No	12.1.1.31				
B>	28.28.28.28/32	7	0	Yes	LSP_DEFAULT	24962
xe5	No	20.1.1.40				
L>	31.31.31.31/32	5	0	Yes	LSP_DEFAULT	24323
xe20	No	12.1.1.31				
L>	41.41.41.41/32	3	0	Yes	LSP_DEFAULT	24320
xe20	No	12.1.1.31				
B	41.41.41.41/32	10	0	Yes	LSP_DEFAULT	24961
-	No	41.41.41.41				
L>	51.51.51.51/32	4	0	Yes	LSP_DEFAULT	3
xe20	No	12.1.1.31				

PE2-ASBR#show ip route bgp

IP Route Table for VRF "default"

B 5.5.5.5/32 [20/3] via 20.1.1.40, xe5, 1d16h38m
 B 28.28.28.28/32 [20/0] via 20.1.1.40, xe5, 1d16h39m

Gateway of last resort is not set

PE2-ASBR#show ip route ospf

IP Route Table for VRF "default"

O 11.1.1.0/24 [110/2] via 12.1.1.31, xe20, 1d16h59m
 O 13.1.1.0/24 [110/2] via 12.1.1.31, xe20, 1d16h59m
 O 31.31.31.31/32 [110/3] via 12.1.1.31, xe20, 1d16h41m
 O 41.41.41.41/32 [110/3] via 12.1.1.31, xe20, 1d16h59m
 O 51.51.51.51/32 [110/2] via 12.1.1.31, xe20, 1d16h59m

Gateway of last resort is not set

PE2-ASBR#show ip route connected

IP Route Table for VRF "default"

```

C          2.2.2.2/32 is directly connected, lo, 1d18h27m
C          12.1.1.0/24 is directly connected, xe20, 1d18h27m
C          20.1.1.0/24 is directly connected, xe5, 1d18h27m
C          127.0.0.0/8 is directly connected, lo, 1d19h32m

```

Gateway of last resort is not set

PE3-ASBR

```

PE3-ASBR#show ip bgp labeled-unicast summary
BGP router identifier 40.40.40.40, local AS number 65001
BGP table version is 7
2 BGP AS-PATH entries
0 BGP community entries

```

Neighbor Down State/PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
5.5.5.5 1d16h46m	1	4 65001	5729	5736	7	0	0	
20.1.1.2 1d16h46m	2	4 65000	5731	5739	7	0	0	

Total number of neighbors 2

Total number of Established sessions 2

```
PE3-ASBR#show ip bgp labeled-unicast
```

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, S - stale

Network	Next Hop	In Label	Out Label
*> 5.5.5.5/32	21.1.1.5	24965	-
*>i 28.28.28.28/32	28.28.28.28	24962	24321
*> 31.31.31.31/32	20.1.1.2	24964	24961
*> 41.41.41.41/32	20.1.1.2	24967	24967

```
PE3-ASBR#sho mpls ilm-table
```

Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, S - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT Intf/VRF Nextthop	ILM-ID	In-Label LSP-Type	Out-Label	In-Intf	Out-
B>	31.31.31.31/32	6	24964	24961	N/A	N/A
	20.1.1.2		LSP_DEFAULT			
B>	28.28.28.28/32	4	24962	24321	N/A	N/A
	28.28.28.28		LSP_DEFAULT			
B>	41.41.41.41/32	9	24967	24967	N/A	N/A
	20.1.1.2		LSP_DEFAULT			
B>	5.5.5.5/32	7	24965	Nolabel	N/A	N/A
	127.0.0.1		LSP_DEFAULT			

```
PE3-ASBR#show mpls forwarding-table
```

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code Label	FEC Out-Intf	ELC	FTN-ID Nexthop	Tunnel-id	Pri	LSP-Type	Out-
L>	5.5.5.5/32		5 0	Yes	LSP_DEFAULT	24320	
xe1	No	21.1.1.5					
L>	6.6.6.6/32		6 0	Yes	LSP_DEFAULT	3	
xe1	No	21.1.1.5					
L>	22.1.1.0/24		7 0	Yes	LSP_DEFAULT	3	
xe1	No	21.1.1.5					
L>	23.1.1.0/24		8 0	Yes	LSP_DEFAULT	3	
xe1	No	21.1.1.5					
L>	28.28.28.28/32		9 0	Yes	LSP_DEFAULT	24321	
xe1	No	21.1.1.5					
B	28.28.28.28/32		2 0	Yes	LSP_DEFAULT	24321	
-	No	28.28.28.28					
B>	31.31.31.31/32		4 0	Yes	LSP_DEFAULT	24961	
xe5	No	20.1.1.2					
B>	41.41.41.41/32		11 0	Yes	LSP_DEFAULT	24967	
xe5	No	20.1.1.2					

```
PE3-ASBR#show ip route bgp
IP Route Table for VRF "default"
B          31.31.31.31/32 [20/3] via 20.1.1.2, xe5, 1d16h46m
B          41.41.41.41/32 [20/0] via 20.1.1.2, xe5, 1d16h23m
```

Gateway of last resort is not set

```
PE3-ASBR#show ip route ospf
IP Route Table for VRF "default"
O          5.5.5.5/32 [110/3] via 21.1.1.5, xe1, 1d16h54m
O          6.6.6.6/32 [110/2] via 21.1.1.5, xe1, 1d16h55m
O          22.1.1.0/24 [110/2] via 21.1.1.5, xe1, 1d16h55m
O          23.1.1.0/24 [110/2] via 21.1.1.5, xe1, 1d16h54m
O          28.28.28.28/32 [110/3] via 21.1.1.5, xe1, 1d16h55m
```

```
PE3-ASBR#show ip route connected
IP Route Table for VRF "default"
C          20.1.1.0/24 is directly connected, xe5, 1d16h55m
C          21.1.1.0/24 is directly connected, xe1, 1d16h55m
C          40.40.40.40/32 is directly connected, lo, 1d16h55m
C          127.0.0.0/8 is directly connected, lo, 1d19h39m
```

Gateway of last resort is not set

RR2

```
RR2#show ip bgp labeled-unicast summary
BGP router identifier 5.5.5.5, local AS number 65001
BGP table version is 10
2 BGP AS-PATH entries
0 BGP community entries
```

Neighbor Down State/PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
28.28.28.28 1d17h00m	1	4 65001	5795	5815	10	0	0	
40.40.40.40 1d16h54m	3	4 65001	5779	5787	10	0	0	

Total number of neighbors 2

Total number of Established sessions 2

RR2#show ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, S - stale

Network	Next Hop	In Label	Out Label
*>i 5.5.5.5/32	40.40.40.40	24325	24965
*>i 28.28.28.28/32	28.28.28.28	24322	24321
*>i 31.31.31.31/32	40.40.40.40	24324	24964
*>i 41.41.41.41/32	40.40.40.40	24327	24967

RR2#show ip bgp vpnv4 all summary

BGP router identifier 5.5.5.5, local AS number 65001

BGP table version is 3

2 BGP AS-PATH entries

0 BGP community entries

Neighbor	Down	State/PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
28.28.28.28			4	65001	5796	5815	3	0	0	
1d17h00m			1							
31.31.31.31			4	65000	5769	5776	3	0	0	
1d16h16m			1							

Total number of neighbors 2

Total number of Established sessions 2

RR2#show ip bgp vpnv4 all

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, l - labeled

S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1					
*> 10.1.1.0/24	41.41.41.41	0	100	0	
65000 ?					
*>i 30.1.1.0/24	28.28.28.28	0	100	0	?
Announced routes count = 0					
Accepted routes count = 2					

RR2#show ip route ospf

IP Route Table for VRF "default"

O	6.6.6.6/32	[110/2]	via 23.1.1.1, xe22, 1d17h02m
O	21.1.1.0/24	[110/2]	via 23.1.1.1, xe22, 1d17h02m
O	22.1.1.0/24	[110/2]	via 23.1.1.1, xe22, 1d17h02m
O	28.28.28.28/32	[110/3]	via 23.1.1.1, xe22, 1d17h02m
O E2	31.31.31.31/32	[110/1]	via 23.1.1.1, xe22, 1d16h54m
O	40.40.40.40/32	[110/3]	via 23.1.1.1, xe22, 1d17h02m

Gateway of last resort is not set

P2

P2#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, S - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT Intf/VRF	NextHop	ILM-ID	In-Label	Out-Label	In-Intf	Out-
				LSP-Type			
L>	5.5.5.5/32		3	24322	Nolabel	N/A	N/A
127.0.0.1			LSP_DEFAULT				
L>	5.5.5.5/32		1	24320	Nolabel	N/A	N/A
127.0.0.1			LSP_DEFAULT				
L>	28.28.28.28/32		2	24321	3	N/A	xe11
22.1.1.28			LSP_DEFAULT				
L>	31.31.31.31/32		4	24323	Nolabel	N/A	N/A
127.0.0.1			LSP_DEFAULT				
L>	40.40.40.40/32		5	24324	3	N/A	xe0
21.1.1.40			LSP_DEFAULT				

PE4

PE4#show ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, S - stale

Network	Next Hop	In Label	Out Label
*>i 5.5.5.5/32	40.40.40.40	24325	24965
*> 28.28.28.28/32	0.0.0.0	24321	-
*>i 31.31.31.31/32	40.40.40.40	24324	24964
*>i 41.41.41.41/32	40.40.40.40	24327	24967

PE4#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-
Label	Out-Intf	ELC	NextHop			
L>	5.5.5.5/32	4	0	Yes	LSP_DEFAULT	24322
xe11	No	22.1.1.5				
B	5.5.5.5/32	3	0	Yes	LSP_DEFAULT	24965
-	No	40.40.40.40				
L>	6.6.6.6/32	5	0	Yes	LSP_DEFAULT	3
xe11	No	22.1.1.5				
L>	21.1.1.0/24	6	0	Yes	LSP_DEFAULT	3
xe11	No	22.1.1.5				
L>	23.1.1.0/24	7	0	Yes	LSP_DEFAULT	3
xe11	No	22.1.1.5				
L>	31.31.31.31/32	8	0	Yes	LSP_DEFAULT	24323
xe11	No	22.1.1.5				
B	31.31.31.31/32	2	0	Yes	LSP_DEFAULT	24964
-	No	40.40.40.40				
L>	40.40.40.40/32	9	0	Yes	LSP_DEFAULT	24324
xe11	No	22.1.1.5				
B>	41.41.41.41/32	11	0	Yes	LSP_DEFAULT	24967
-	No	40.40.40.40				

PE4#show ip bgp vpnv4 all summary


```

BGP router identifier 28.28.28.28, local AS number 65001
BGP table version is 2
2 BGP AS-PATH entries
0 BGP community entries

```

Neighbor	Down	State/PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
5.5.5.5			4	65001	5792	5781	2	0	0	
1d17h08m			1							

Total number of neighbors 1

Total number of Established sessions 1

```

PE4#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

```

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (Default for VRF vrf1)					
*>i 10.1.1.0/24	41.41.41.41	0	100	0	
65000 ?					
*> 1 30.1.1.0/24	0.0.0.0	0	100	32768	?
Announced routes count = 1					
Accepted routes count = 1					
Route Distinguisher: 1:1					
*>i 10.1.1.0/24	41.41.41.41	0	100	0	
65000 ?					
Announced routes count = 0					
Accepted routes count = 1					

```

PE4#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info

```

```

IP Route Table for VRF "vrf1"
B    *> 10.1.1.0/24 [200/0] via 41.41.41.41, 1d16h23m
C    *> 30.1.1.0/24 is directly connected, xe21, 1d16h35m

```

Gateway of last resort is not set

Inter-AS VPN Option-C Configuration (Without RR)

This sub-option enables VPNv4 routes exchange between the Provider Edge Routers of different AS'es and thus requires

1. Remote PE loopback addresses to be known in the AS - This is accomplished using BGP-LU and is advertised inside the AS using the Route-reflector and outside the AS using the eBGP Peering between the ASBRs.

2. Next-hop attribute should be changed when ASBR advertises the remote PE's Loopback address as LU route to the RR. This is accomplished using the configuration "next-hop self" for the iBGP RR neighbor.
 3. MP-eBGP session between the two PE's in different AS's to exchange the VPNv4 routes.
- (1) and (2) enables an end to end LSP between the two PE's which needs to run the L3VPN service and (3) enables the PE's in different AS'es to form BGP neighborhood with each other and successfully exchange the VPNv4 Routes.

Topology

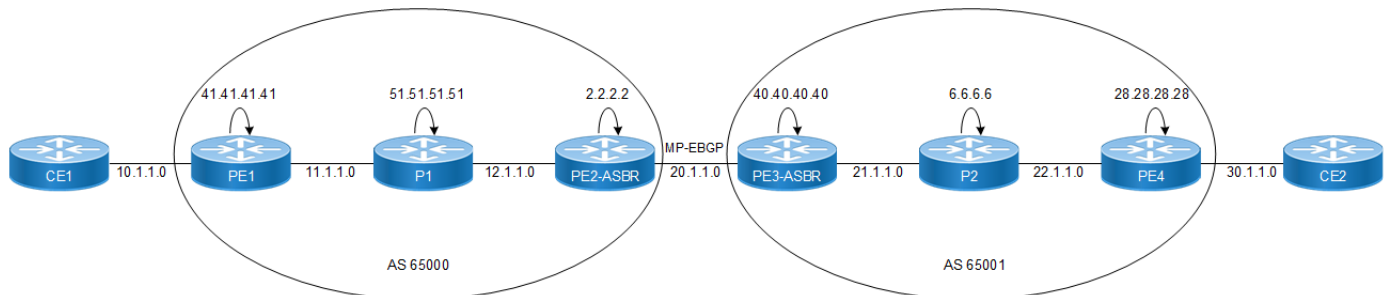


Figure 14-5: InterAS-VPN Option-C without RR

PE1

#configure terminal	Enter configure mode.
PE1(config)#interface lo	Enter interface mode.
PE1(config-if)#ip address 41.41.41.41/32 secondary	Assign the IPv4 address.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#ip vrf vrf1	Create a new VRF named vrf1.
PE1(config-vrf)#rd 1:1	Assign the route distinguisher (RD) value as 1:1.
PE1(config-vrf)#route-target both 1:1	Configure import and export RT for this VRF.
PE1(config-vrf)#exit	Exit interface mode.
PE1(config)#interface xe23	Enter interface mode.
PE1(config-if)#ip vrf forwarding vrf1	Bind the interface connected to the CE router with VRF vrf1.
PE1(config-if)#ip address 10.1.1.1/24	Assign the IPv4 address.
PE1(config)#interface xe15	Enter interface mode.
PE1(config-if)#ip address 11.1.1.41/24	Assign the IPv4 address.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#router ospf 1	Enter router OSPF mode.
PE1(config-router)#ospf router-id 41.41.41.41	Configure OSPF router id same as loopback ip address.
PE1(config-router)#network 11.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE1(config-router)#network 41.41.41.41/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE1(config-router)#exit	Exit OSPF router mode.
PE1(config-router)#router ldp	Enter router LDP mode.

PE1(config-router)#router-id 41.41.41.41	Set the router ID to IP address 41.41.41.41
PE1(config-router)#transport-address ipv4 41.41.41.41	Configure LDP transport address same as loopback address
PE1(config-router)#exit	Exit LDP mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#exit	Exit interface mode.
PE1(config-if)#router bgp 65000	Enter BGP router mode.
PE1(config-router)# bgp router-id 41.41.41.41	Configure BGP router-id.
PE1(config-router)# no bgp default ipv4-unicast	Configure BGP peer to have no ipv4 unicast capability exchange by default.
PE1(config-router)# address-family ipv4 unicast	Enter address-family ipv4 unicast.
PE1(config-router-af)# network 41.41.41.41/32	Advertise loopback address.
PE1(config-router-af)# exit-address-family	Exit address-family ipv4 labeled-unicast.
PE1(config-router)# neighbor 2.2.2.2 re-remote-as 65000	Configure PE2-ASBR1 as an iBGP peer.
PE1(config-router)# neighbor 2.2.2.2 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
PE1(config-router)# neighbor 28.28.28.28 remote-as 65001	Configure PE4 as an eBGP peer.
PE1(config-router)# neighbor 28.28.28.28 ebgp-multihop	Configure eBGP multichip for eBGP peer PE4.
PE1(config-router)# neighbor 28.28.28.28 update-source lo	Update the source as loopback for eBGP peering with the remote PE4 router.
PE1(config-router)# allocate-label all	Configure allocate-label.
PE1(config-router)# address-family ipv4 la-beled-unicast	Enter address-family ipv4 labeled-unicast.
PE1(config-router-af)# neighbor 2.2.2.2 ac-tivate	Activate iBGP neighbor.
PE1(config-router-af)# exit-address-family	Exit address-family ipv4 labeled-unicast.
PE1(config-router)# address-family vpnv4 unicast	Enter address-family vpnv4.
PE1(config-router-af)# neighbor 28.28.28.28 allow-ebgp-vpn	Configure allow-ebgp-vpn for ebgp neighbor PE4.
PE1(config-router-af)# neighbor 28.28.28.28 activate	Activate eBGP neighbor PE4.
PE1(config-router-af)# exit-address-family	Exit address-family vpnv4.
PE1(config-router)# address-family ipv4 vrf vrf1	Enter the IPv4 address family for VRF vrf1.
PE1(config-router-af)# redistribute con-nected	Redistribute connected route.
PE1(config-router-af)# exit-address-family	Exit IPv4 VRF Address Family mode.
PE1(config-router)#exit	Exit the router mode.

PE1(config)#commit	Commit candidate configuration to be running configuration.
PE1(config)#exit	Exit the config mode.

P1

P1#configure terminal	Enter configure mode.
P1(config)#interface lo	Enter interface mode.
P1(config-if)# ip address 51.51.51.51/32 secondary	Assign the IPv4 address.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface xe15	Enter interface mode.
P1(config-if)#ip address 11.1.1.31/24	Assign the IPv4 address.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface xe21	Enter interface mode.
P1(config-if)#ip address 12.1.1.31/24	Assign the IPv4 address.
P1(config-if)#exit	Exit interface mode.
P1(config)#router ospf 1	Enter router OSPF mode.
P1(config-router)#ospf router-id 51.51.51.51	Configure OSPF router id same as loopback ip address.
P1(config-router)#network 11.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
P1(config-router)#network 12.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
P1(config-router)#network 51.51.51.51/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
P1(config-router)#exit	Exit router OSPF mode.
P1(config-router)#router ldp	Enter router LDP mode.
P1(config-router)#router-id 51.51.51.51	Set the router ID to IP address 51.51.51.51
P1(config-router)#transport-address ipv4 51.51.51.51	Configure LDP transport address same as loopback address
P1(config-router)#exit	Exit LDP mode.
P1(config)#interface xe15	Enter interface mode.
P1(config-if)#label-switching	Enable label switching in interface.
P1(config-if)# enable-ldp ipv4	Enable LDP on the interface.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface xe21	Enter interface mode.
P1(config-if)#label-switching	Enable label switching in interface.
P1(config-if)# enable-ldp ipv4	Enable LDP on the interface.
P1(config-if)#exit	Exit interface mode.
P1(config)#commit	Commit candidate configuration to be running configuration.
P1(config)#exit	Exit the config mode.

PE2-ASBR1

#configure terminal	Enter configure mode.
PE2-ASBR(config)#interface lo	Enter interface mode.
PE2-ASBR(config-if)#ip address 2.2.2.2/32 secondary	Assign the IPv4 address.
PE2-ASBR(config-if)#exit	Exit interface mode.
PE2-ASBR(config)#router ospf 1	Enter router OSPF mode.
PE2-ASBR(config-router)#ospf router-id 2.2.2.2	Configure OSPF router id same as loopback ip address.
PE2-ASBR(config-router)#network 2.2.2.2/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE2-ASBR(config-router)#network 12.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE2-ASBR(config-router)#exit	Exit router OSPF mode.
PE2-ASBR(config-router)#router ldp	Enter router LDP mode.
PE2-ASBR(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2
PE2-ASBR(config-router)#transport-address ipv4 2.2.2.2	Configure LDP transport address same as loopback address.
PE2-ASBR(config-router)#exit	Exit LPD mode.
PE2-ASBR(config)#interface xe5	Enter interface mode.
PE2-ASBR(config-if)#ip address 20.1.1.2/24	Assign the IPv4 address.
PE2-ASBR(config-if)#label-switching	Enable label switching in interface.
PE2-ASBR(config-if)#exit	Exit interface mode.
PE2-ASBR(config)#interface xe20	Enter interface mode.
PE2-ASBR(config-if)#ip address 12.1.1.2/24	Assign the IPv4 address.
PE2-ASBR(config-if)#label-switching	Enable label switching in interface.
PE2-ASBR(config-if)# enable-ldp ipv4	Enable LDP on the interface.
PE2-ASBR(config-if)#exit	Exit interface mode
PE2-ASBR(config-if)#router bgp 65000	Enter BGP router mode.
PE2-ASBR(config-router)# bgp router-id 2.2.2.2	Configure BGP router-id.
PE2-ASBR(config-router)# no bgp default ipv4-unicast	Configure BGP to have no default ipv4 unicast capability exchange between neighbors.
PE2-ASBR(config-router)# neighbor 20.1.1.40 remote-as 65001	Configure PE3-ASBR2 as an eBGP peer.
PE2-ASBR(config-router)# neighbor 41.41.41.41 remote-as 65000	Configure PE1 as an iBGP peer.
PE2-ASBR(config-router)# neighbor 41.41.41.41 update-source lo	Update the source as loopback for iBGP peering with the remote PE1 router.
PE2-ASBR(config-router)# allocate-label all	Configure allocate-label.
PE2-ASBR(config-router)# address-family ipv4 labeled-unicast	Enter address-family ipv4 labeled-unicast.
PE2-ASBR(config-router-af)# neighbor 20.1.1.40 activate	Activate eBGP neighbor PE3-ASBR2.

PE2-ASBR(config-router-af)# neighbor 41.41.41.41 activate	Activate iBGP neighbor PE1.
PE2-ASBR(config-router-af)# neighbor 41.41.41.41 next-hop-self	Configure next-hop-self for iBGP neighbor PE1.
PE2-ASBR(config-router-af)# exit-address-family	Exit address-family ipv4 labeled-unicast.
PE2(config-router)#exit	Exit the router mode.
PE2(config)#commit	Commit candidate configuration to be running configuration.
PE2(config)#exit	Exit the config mode.

PE3-ASBR

PE3-ASBR#configure terminal	Enter configure mode.
PE3-ASBR(config)#interface lo	Enter interface mode.
PE3-ASBR(config-if)#ip address 40.40.40.40/32 secondary	Assign the IPv4 address.
PE3-ASBR(config-if)#exit	Exit interface mode.
PE3-ASBR(config)#interface xe5	Enter interface mode.
PE3-ASBR(config-if)#ip address 20.1.1.40/24	Assign the IPv4 address.
PE3-ASBR(config-if)#exit	Exit interface mode.
PE3-ASBR(config)#interface xe1	Enter interface mode.
PE3-ASBR(config-if)#ip address 21.1.1.40/24	Assign the IPv4 address.
PE3-ASBR(config-if)#exit	Exit interface mode.
PE3-ASBR(config)#router ospf 1	Enter router OSPF mode.
PE3-ASBR(config-router)#ospf router-id 40.40.40.40	Configure OSPF router id same as loopback ip address.
PE3-ASBR(config-router)#network 21.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE3-ASBR(config-router)#network 40.40.40.40/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE3-ASBR(config-router)#exit	Exit router OSPF mode.
PE3-ASBR(config-router)#router ldp	Enter router LDP mode.
PE3-ASBR(config-router)#router-id 40.40.40.40	Set the router ID to IP address 40.40.40.40
PE3-ASBR(config-router)#transport-address ipv4 40.40.40.40	Configure LDP transport address same as loopback address
PE3-ASBR(config)#interface xe1	Enter interface mode.
PE3-ASBR(config-if)#label-switching	Enable label switching in interface.
PE3-ASBR(config-if)#enable-ldp ipv4	Enable LDP on the interface.
PE3-ASBR(config)#interface xe5	Enter interface mode.
PE3-ASBR(config-if)#label-switching	Enable label switching in interface.
PE3-ASBR(config-if)#router bgp 65001	Enter BGP router mode.
PE3-ASBR(config-router)# bgp router-id 40.40.40.40	Configure BGP router-id.

PE3-ASBR(config-router)# no bgp default ipv4-unicast	Configure BGP to have no default ipv4 unicast capability exchange with the neighbors.
PE3-ASBR(config-router)# neighbor 20.1.1.2 remote-as 65000	Configure PE2-ASBR as an eBGP peer.
PE3-ASBR(config-router)# neighbor 28.28.28.28 remote-as 65001	Configure PE4 as an iBGP peer.
PE3-ASBR(config-router)# neighbor 28.28.28.28 update-source lo	Update the source as loopback for iBGP peering with the remote PE4 router.
PE3-ASBR(config-router)# allocate-label all	Configure allocate-label.
PE3-ASBR(config-router)# address-family ipv4 labeled-unicast	Enter address-family ipv4 labeled-unicast.
PE3-ASBR(config-router-af)# neighbor 20.1.1.2 activate	Activate eBGP neighbor PE2-ASBR1.
PE3-ASBR(config-router-af)# neighbor 28.28.28.28 activate	Activate iBGP neighbor PE4.
PE3-ASBR(config-router-af)# neighbor 28.28.28.28 next-hop-self	Configure next-hop-self for iBGP neighbor PE4.
PE3-ASBR(config-router-af)# exit-address- family	Exit address-family ipv4 labeled-unicast.
PE3-ASBR(config-router)#exit	Exit the router mode.
PE3-ASBR(config)#commit	Commit candidate configuration to be running configuration.
PE3-ASBR(config)#exit	Exit the config mode.

P2

#configure terminal	Enter configure mode.
P2(config)#interface lo	Enter interface mode.
P2(config-if)# ip address 6.6.6.6/32 secondary	Assign the IPv4 address.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface xe0	Enter interface mode.
P2(config-if)#ip address 21.1.1.5/24	Assign the IPv4 address.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface xel1	Enter interface mode.
P2(config-if)#ip address 22.1.1.5/24	Assign the IPv4 address.
P2(config-if)#exit	Exit interface mode.
P2(config)#router ospf 1	Enter router OSPF mode.
P2(config-router)#ospf router-id 6.6.6.6	Configure OSPF router id same as loopback ip address.
P2(config-router)# network 6.6.6.6/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
P2(config-router)#network 21.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
P2(config-router)#network 22.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
P2(config-router)#exit	Exit router OSPF mode.
P2(config)#router ldp	Enter router LDP mode.

P2(config-router)#router-id 6.6.6.6	Set the router ID to IP address 6.6.6.6
P2(config-router)#transport-address ipv4 6.6.6.6	Configure LDP transport address same as loopback address
P2(config-router)#exit	Exit LDP mode.
P2(config)#interface xe0	Enter interface mode.
P2(config-if)#label-switching	Enable label switching in interface.
P2(config-if)# enable-ldp ipv4	Enable LDP on the interface.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface xel1	Enter interface mode.
P2(config-if)#label-switching	Enable label switching in interface.
P2(config-if)# enable-ldp ipv4	Enable LDP on the interface.
P2(config-if)#exit	Exit interface mode.
P2(config)#commit	Commit candidate configuration to be running configuration.
P2(config)#exit	Exit the config mode.

PE4

#configure terminal	Enter configure mode.
PE4(config)#interface lo	Enter interface mode.
PE4(config-if)#ip address 28.28.28.28/32 secondary	Assign the IPv4 address.
PE4(config-if)#exit	Exit interface mode.
PE4(config)#ip vrf vrf1	Create a new VRF named vrf1.
PE4(config-vrf)#rd 1:1	Assign the route distinguisher (RD) value as 1:1.
PE4(config-vrf)#route-target both 1:1	Configure import and export RTs for the VRF.
PE4(config-vrf)#exit	Exit VRF mode.
PE4(config)#interface xe23	Enter interface mode.
PE4(config-if)#ip vrf forwarding vrf1	Bind the interface connected to the CE router with VRF vrf1.
PE4(config-if)#ip address 30.1.1.1/24	Assign the IPv4 address.
PE4(config-if)#exit	Exit interface mode.
PE4(config)#interface xel1	Enter interface mode.
PE4(config-if)#ip address 22.1.1.28/24	Assign the IPv4 address.
PE4(config-if)#exit	Exit interface mode.
PE4(config)#router ospf 1	Enter router OSPF mode.
PE4(config-router)#ospf router-id 28.28.28.28	Configure OSPF router id same as loopback ip address.
PE4(config-router)#network 22.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE4(config-router)#network 28.28.28.28/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE4(config-router)#exit	Exit OSPF router mode.
PE4(config)# router ldp	Enter router LDP mode.
PE4(config-router)#router-id 28.28.28.28	Set the router ID to IP address 28.28.28.28

PE4(config-router)#transport-address ipv4 28.28.28.28	Configure LDP transport address same as loopback address
PE4(config-router)#exit	Exit LDP mode.
PE4(config)#interface xe11	Enter interface mode.
PE4(config-if)#label-switching	Enable label switching in interface.
PE4(config-if)# enable-ldp ipv4	Enable LDP on the interface.
PE4(config-if)#exit	Exit interface mode.
PE4(config-if)#router bgp 65001	Enter BGP router mode.
PE4(config-router)# bgp router-id 28.28.28.28	Configure BGP router-id.
PE4(config-router)# no bgp default ipv4-unicast	Configure BGP speaker to have no default ipv4 unicast capability exchange between neighbors.
PE4(config-router)#address-family ipv4 unicast	Enter the IPv4 unicast address family.
PE4(config-router-af)#network 28.28.28.28/32	Advertise loopback address.
PE4(config-router-af)#exit-address-family	Exit address family mode
PE4(config-router)# neighbor 40.40.40.40 remote-as 65001	Configure PE3-ASBR2 as an iBGP peer.
PE4(config-router)# neighbor 40.40.40.40 update-source lo	Update the source as loopback for iBGP peering with the remote PE3-ASBR router.
PE4(config-router)# neighbor 41.41.41.41 remote-as 65000	Configure PE1 as an eBGP peer.
PE4(config-router)# neighbor 41.41.41.41 ebgp-multihop	Configure eBGP multichip for eBGP peer PE1.
PE4(config-router)# neighbor 41.41.41.41 update-source lo	Update the source as loopback for eBGP peering with the remote PE1 router.
PE4(config-router)# allocate-label all	Configure allocate-label.
PE4(config-router)# address-family ipv4 la-beled-unicast	Enter address-family ipv4 labeled-unicast.
PE4(config-router-af)# neighbor 40.40.40.40 activate	Activate iBGP neighbor.
PE4(config-router-af)# exit-address-family	Exit address-family ipv4 labeled-unicast.
PE4(config-router)# address-family vpnv4 unicast	Enter address-family vpnv4.
PE4(config-router-af)# neighbor 41.41.41.41 allow-ebgp-vpn	Activate eBGP neighbor PE1.
PE4(config-router-af)# neighbor 41.41.41.41 activate	Configure allow-ebgp-vpn for ebgp neighbor PE1.
PE4(config-router-af)# exit-address-family	Exit address-family vpnv4.
PE4(config-router)# address-family ipv4 vrf vrf1	Enter the IPv4 address family for VRF vrf1.
PE4(config-router-af)# redistribute con-nected	Redistribute connected route.
PE4(config-router-af)# exit-address-family	Exit IPv4 VRF Address Family mode.
PE4(config-router)#exit	Exit the router mode.

PE4 (config) #commit	Commit candidate configuration to be running configuration.
PE4 (config) #exit	Exit the config mode.

Validation

PE1

```
PE1#show ip bgp labeled-unicast summary
BGP router identifier 41.41.41.41, local AS number 65000
BGP table version is 10
2 BGP AS-PATH entries
0 BGP community entries
```

Neighbor	Down	State/PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
2.2.2.2			4	65000	374	368	10	0	0	
02:37:43			3							

Total number of neighbors 1

Total number of Established sessions 1

```
PE1#show ip bgp labeled-unicast
```

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, S - stale

Network	Next Hop	In Label	Out Label
*>i 5.5.5.5/32	2.2.2.2	24960	24965
*>i 28.28.28.28/32	2.2.2.2	24962	24962
*>i 31.31.31.31/32	2.2.2.2	24963	24961
*> 41.41.41.41/32	0.0.0.0	24961	-

```
PE1#show ip route bgp
IP Route Table for VRF "default"
B          28.28.28.28/32 [200/0] via 2.2.2.2 (recursive via 11.1.1.31),
02:41:00
```

Gateway of last resort is not set

```
PE1#show mpls forwarding-table
```

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-
Label	Out-Intf	ELC	Nexthop			
L>	2.2.2.2/32	4	0	Yes	LSP_DEFAULT	24321
xe15	No	11.1.1.31				
L>	5.5.5.5/32	6	0	Yes	LSP_DEFAULT	24324
xe15	No	11.1.1.31				
B	5.5.5.5/32	7	0	Yes	LSP_DEFAULT	24965
-	No	2.2.2.2				
L>	12.1.1.0/24	2	0	Yes	LSP_DEFAULT	3
xe15	No	11.1.1.31				
L>	13.1.1.0/24	3	0	Yes	LSP_DEFAULT	3
xe15	No	11.1.1.31				

```

- B> 28.28.28.28/32      8      0      Yes  LSP_DEFAULT  24962
-   No      2.2.2.2
L> 31.31.31.31/32      5      0      Yes  LSP_DEFAULT  24322
xe15 No      11.1.1.31
- B 31.31.31.31/32      9      0      Yes  LSP_DEFAULT  24961
-   No      2.2.2.2
L> 51.51.51.51/32      1      0      Yes  LSP_DEFAULT  3
xe15 No      11.1.1.31

```

```

PE1#show ip bgp vpnv4 all summary
BGP router identifier 41.41.41.41, local AS number 65000
BGP table version is 4
2 BGP AS-PATH entries
0 BGP community entries

```

Neighbor	Down	State/PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
28.28.28.28			4	65001	340	338	4	0	0	
02:22:11			1							

Total number of neighbors 1

Total number of Established sessions 1

```

PE1#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

```

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (Default for VRF vrfl)					
*> 1 10.1.1.0/24	0.0.0.0	0	100	32768	?
*> 30.1.1.0/24	28.28.28.28	0	100	0	
65001 ?					
Announced routes count = 1					
Accepted routes count = 1					
Route Distinguisher: 1:1					
*> 30.1.1.0/24	28.28.28.28	0	100	0	
65001 ?					
Announced routes count = 0					
Accepted routes count = 1					

```

PE1#show ip route vrf vrfl database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info

```

```

IP Route Table for VRF "vrfl"
C   *> 10.1.1.0/24 is directly connected, xe23, 1d19h57m
B   *> 30.1.1.0/24 [20/0] via 28.28.28.28, 02:22:28

```

Gateway of last resort is not set

P1

```

P1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
       K - CLI ILM, T - MPLS-TP, S - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

```

Code Intf/VRF	FEC/VRF/L2CKT Nexthop	ILM-ID	In-Label LSP-Type	Out-Label	In-Intf	Out-
L> 12.1.1.2	2.2.2.2/32	2	24321	3	N/A	xe21
L> 11.1.1.2	41.41.41.41/32	1	24320	3	N/A	xe15
L> 127.0.0.1	31.31.31.31/32	4	24323	Nolabel	N/A	N/A
L> 127.0.0.1	31.31.31.31/32	3	24322	Nolabel	N/A	N/A
L> 127.0.0.1	5.5.5.5/32	5	24324	Nolabel	N/A	N/A

PE2-ASBR

```

PE2-ASBR#show ip bgp labeled-unicast summary
BGP router identifier 2.2.2.2, local AS number 65000
BGP table version is 10
2 BGP AS-PATH entries
0 BGP community entries

```

Neighbor Down State/PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
20.1.1.40 1d20h28m	2	4 65001	6427	6521	10	0	0	
41.41.41.41 02:42:38	1	4 65000	379	385	10	0	0	

Total number of neighbors 2

Total number of Established sessions 2

```

PE2-ASBR#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
       K - CLI ILM, T - MPLS-TP, S - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

```

Code Intf/VRF	FEC/VRF/L2CKT Nexthop	ILM-ID	In-Label LSP-Type	Out-Label	In-Intf	Out-
B> 127.0.0.1	31.31.31.31/32	2	24961	Nolabel	N/A	N/A
B> 41.41.41.41	41.41.41.41/32	1	24960	24961	N/A	N/A
B> 20.1.1.40	5.5.5.5/32	6	24965	24965	N/A	N/A
B> 20.1.1.40	28.28.28.28/32	3	24962	24961	N/A	N/A

```
PE2-ASBR#show mpls forwarding-table
```

```
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
```

Code Label	FEC Out-Intf	ELC	FTN-ID Nextthop	Tunnel-id	Pri	LSP-Type	Out-
B> xe5	5.5.5.5/32	No	8 20.1.1.40	0	Yes	LSP_DEFAULT	24965
L> xe20	11.1.1.0/24	No	1 12.1.1.31	0	Yes	LSP_DEFAULT	3
L> xe20	13.1.1.0/24	No	2 12.1.1.31	0	Yes	LSP_DEFAULT	3
B> xe5	28.28.28.28/32	No	7 20.1.1.40	0	Yes	LSP_DEFAULT	24961
L> xe20	31.31.31.31/32	No	5 12.1.1.31	0	Yes	LSP_DEFAULT	24323
L> xe20	41.41.41.41/32	No	3 12.1.1.31	0	Yes	LSP_DEFAULT	24320
B -	41.41.41.41/32	No	6 41.41.41.41	0	Yes	LSP_DEFAULT	24961
L> xe20	51.51.51.51/32	No	4 12.1.1.31	0	Yes	LSP_DEFAULT	3

```
PE2-ASBR#show ip route bgp
```

```
IP Route Table for VRF "default"
```

```
B 28.28.28.28/32 [20/0] via 20.1.1.40, xe5, 02:41:38
```

```
Gateway of last resort is not set
```

PE3-ASBR

```
PE3-ASBR#show ip bgp labeled-unicast summary
```

```
BGP router identifier 40.40.40.40, local AS number 65001
```

```
BGP table version is 11
```

```
2 BGP AS-PATH entries
```

```
0 BGP community entries
```

Neighbor	Down State/PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
20.1.1.2			4	65000	6263	6267	11	0	0
1d20h31m		2							
28.28.28.28			4	65001	383	389	11	0	0
02:42:56		1							

```
Total number of neighbors 2
```

```
Total number of Established sessions 2
```

```
PE3-ASBR#show mpls ilm-table
```

```
Codes: > - installed ILM, * - selected ILM, p - stale ILM
```

```
K - CLI ILM, T - MPLS-TP, S - Stitched ILM
```

```
S - SNMP, L - LDP, R - RSVP, C - CRLDP
```

```
B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
```

```
O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
```

```
P - SR Policy, U - unknown
```

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-
Intf/VRF	Nextthop		LSP-Type			

```

B> 31.31.31.31/32      6      24964      24961      N/A      N/A
20.1.1.2      LSP_DEFAULT
B> 41.41.41.41/32      2      24960      24960      N/A      N/A
20.1.1.2      LSP_DEFAULT
B> 28.28.28.28/32      3      24961      24321      N/A      N/A
28.28.28.28      LSP_DEFAULT
B> 5.5.5.5/32          7      24965      Nolabel    N/A      N/A
127.0.0.1      LSP_DEFAULT

```

PE3-ASBR#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code Label	FEC Out-Intf	ELC	FTN-ID Nexthop	Tunnel-id	Pri	LSP-Type	Out-
L>	5.5.5.5/32		5	0	Yes	LSP_DEFAULT	24320
xe1	No	21.1.1.5					
L>	6.6.6.6/32		6	0	Yes	LSP_DEFAULT	3
xe1	No	21.1.1.5					
L>	22.1.1.0/24		7	0	Yes	LSP_DEFAULT	3
xe1	No	21.1.1.5					
L>	23.1.1.0/24		8	0	Yes	LSP_DEFAULT	3
xe1	No	21.1.1.5					
L>	28.28.28.28/32		9	0	Yes	LSP_DEFAULT	24321
xe1	No	21.1.1.5					
B	28.28.28.28/32		2	0	Yes	LSP_DEFAULT	24321
-	No	28.28.28.28					
B>	31.31.31.31/32		4	0	Yes	LSP_DEFAULT	24961
xe5	No	20.1.1.2					
B>	41.41.41.41/32		1	0	Yes	LSP_DEFAULT	24960
xe5	No	20.1.1.2					

PE3-ASBR#show ip route bgp

IP Route Table for VRF "default"

B 41.41.41.41/32 [20/0] via 20.1.1.2, xe5, 02:45:37

Gateway of last resort is not set

P2

P2#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, S - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

Code Intf/VRF	FEC/VRF/L2CKT Nexthop	ILM-ID	In-Label LSP-Type	Out-Label	In-Intf	Out-
L>	5.5.5.5/32	3	24322	Nolabel	N/A	N/A
127.0.0.1			LSP_DEFAULT			
L>	5.5.5.5/32	1	24320	Nolabel	N/A	N/A
127.0.0.1			LSP_DEFAULT			
L>	28.28.28.28/32	2	24321	3	N/A	xe11
22.1.1.28			LSP_DEFAULT			
L>	31.31.31.31/32	4	24323	Nolabel	N/A	N/A
127.0.0.1			LSP_DEFAULT			

```

L> 40.40.40.40/32      5      24324      3      N/A      xe0
21.1.1.40      LSP_DEFAULT

```

PE4

```

PE4#show ip bgp labeled-unicast summary
BGP router identifier 28.28.28.28, local AS number 65001
BGP table version is 12
2 BGP AS-PATH entries
0 BGP community entries

```

Neighbor	Down	State/PfxRcd	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
40.40.40.40			4	65001	404	399	12	0	0	
02:49:41			3							

Total number of neighbors 1

Total number of Established sessions 1

```

PE4#show ip bgp labeled-unicast

```

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, S - stale

Network	Next Hop	In Label	Out Label
*>i 5.5.5.5/32	40.40.40.40	24324	24965
*> 28.28.28.28/32	0.0.0.0	24321	-
*>i 31.31.31.31/32	40.40.40.40	24322	24964
*>i 41.41.41.41/32	40.40.40.40	24323	24960

```

PE4#

```

```

PE4#show mpls forwarding-table

```

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-
Label	Out-Intf	ELC	Nexthop			
L>	5.5.5.5/32	4	0	Yes	LSP_DEFAULT	24322
xe11	No	22.1.1.5				
B	5.5.5.5/32	3	0	Yes	LSP_DEFAULT	24965
-	No	40.40.40.40				
L>	6.6.6.6/32	5	0	Yes	LSP_DEFAULT	3
xe11	No	22.1.1.5				
L>	21.1.1.0/24	6	0	Yes	LSP_DEFAULT	3
xe11	No	22.1.1.5				
L>	23.1.1.0/24	7	0	Yes	LSP_DEFAULT	3
xe11	No	22.1.1.5				
L>	31.31.31.31/32	8	0	Yes	LSP_DEFAULT	24323
xe11	No	22.1.1.5				
B	31.31.31.31/32	1	0	Yes	LSP_DEFAULT	24964
-	No	40.40.40.40				
L>	40.40.40.40/32	9	0	Yes	LSP_DEFAULT	24324
xe11	No	22.1.1.5				
B>	41.41.41.41/32	2	0	Yes	LSP_DEFAULT	24960
-	No	40.40.40.40				

```

PE4#show ip bgp vpnv4 all summary
BGP router identifier 28.28.28.28, local AS number 65001

```

BGP table version is 4
 2 BGP AS-PATH entries
 0 BGP community entries

Neighbor	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/
Down State/PfxRcd								
41.41.41.41	4	65000	373	376	4	0	0	
02:37:04	1							

Total number of neighbors 1

Total number of Established sessions 1

PE4#show ip bgp vpnv4 all
 Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, l - labeled
 S Stale
 Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (Default for VRF vrf1)					
*> 10.1.1.0/24	41.41.41.41	0	100	0	
65000 ?					
*> 1 30.1.1.0/24	0.0.0.0	0	100	32768	?
Announced routes count = 1					
Accepted routes count = 1					
Route Distinguisher: 1:1					
*> 10.1.1.0/24	41.41.41.41	0	100	0	
65000 ?					
Announced routes count = 0					
Accepted routes count = 1					

PE4#show ip route vrf vrf1 database
 Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
 O - OSPF, IA - OSPF inter area
 N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
 E1 - OSPF external type 1, E2 - OSPF external type 2
 i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
 ia - IS-IS inter area, E - EVPN,
 v - vrf leaked
 > - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"
 B *> 10.1.1.0/24 [20/0] via 41.41.41.41, 02:37:23
 C *> 30.1.1.0/24 is directly connected, xe21, 1d20h11m

Gateway of last resort is not set

PE4#show mpls ilm-table
 Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, S - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-
Intf/VRF	Nexthop		LSP-Type			

B> 41.41.41.41/32	4	24323	24960	N/A	N/A
40.40.40.40		LSP_DEFAULT			
B> 28.28.28.28/32	2	24321	Nolabel	N/A	N/A
127.0.0.1		LSP_DEFAULT			
B> vrf1	1	24320	Nolabel	N/A	vrf1
N/A		LSP_DEFAULT			
B> 31.31.31.31/32	3	24322	24964	N/A	N/A
40.40.40.40		LSP_DEFAULT			
B> 5.5.5.5/32	5	24324	24965	N/A	N/A
40.40.40.40		LSP_DEFAULT			

CHAPTER 15 MPLS Service Mapping Configuration

This chapter includes step-by-step configurations for tunnel policy configuration for all the MPLS services.

Overview

This feature enables MPLS services L2VPN, L3VPN, EVPN traffic steering with SR-policy as the underlying transport using local-tunnel-policy configuration. This is achieved with the help of color coding and association between service and MPLS transport.

A local-tunnel-policy is created which specifies the color of the transport-tunnel in order to be selected for a VPN service. The created tunnel-policy is now applied for the VPN service so that it will select the preferred tunnel. The destination address of the preferred tunnel identifies a peer PE so the PE will forward traffic destined for that peer PE over the preferred tunnel. If you specify multiple preferred tunnels that have the same destination address in a tunnel policy, only the first configured tunnel takes effect and if the first tunnel is not available, the second tunnel is used, and so forth. No load balancing will be performed on these tunnels.

The tunnels selected by 2 methods, dedicated and best-effort. By default, tunnel policy uses dedicated method. If you configure dedicated method for a tunnel policy, the tunnel policy uses the preferred tunnel to forward traffic destined for the peer PE. If not, the MPLS VPN service will be down. If you configure best-effort method for a tunnel policy, the tunnel policy uses the preferred tunnel to forward traffic destined for the peer PE. If not, the MPLS VPN selects the available MPLS transport in MPLS forwarding table.

Topology

The diagram depicts the topology for the configuration examples that follow.

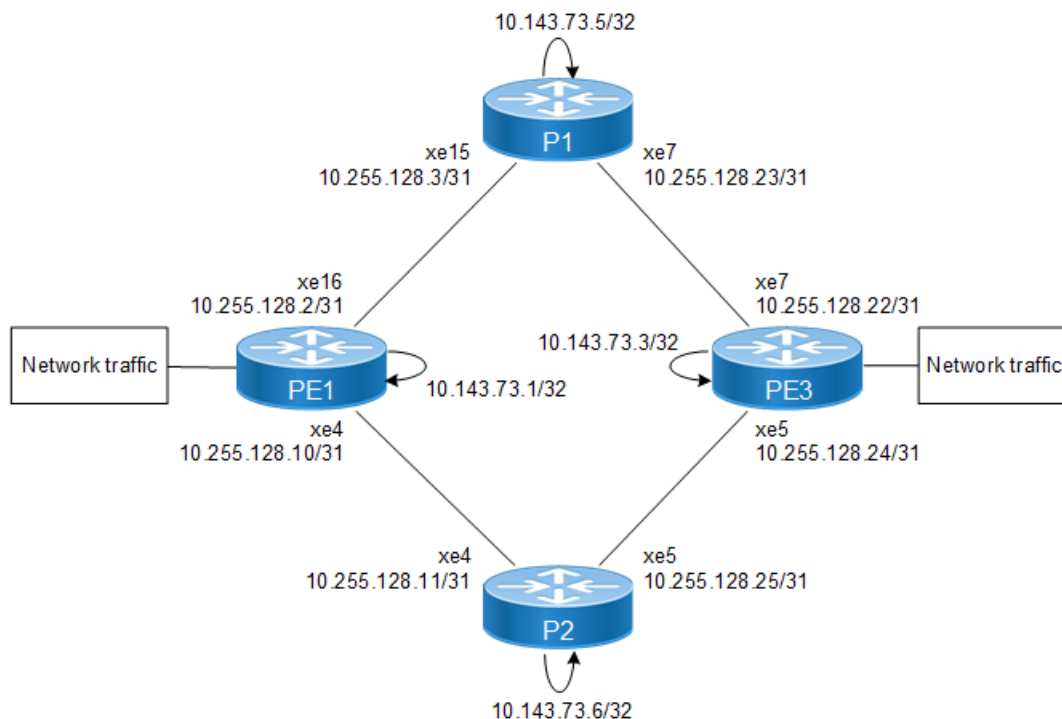


Figure 15-6: Service mapping to Tunnel

Configuration

Below are the sample configuration for EVPN (E-LINE, E-LAN), L3VPN, 6VPE, VPWS, and VPLS services with Tunnel Policy along with SR as transport.

PE1: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.1/32 secondary	Configure IP address on loopback interface.
(config-if)#prefix-sid index 1	Configure prefix sid index value
(config-if)#exit	Exit interface mode

PE1: Global EVPN MPLS Command:

#configure terminal	Enter configuration mode.
(config)#evpn mpls enable	Enable EVPN MPLS. Note: Reload is required after Enabling/Disabling EVPN MPLS Feature.
(config)#evpn mpls vtep-ip-global 10.143.73.1	Configuring loopback IP as VTEP global IP
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Ending config mode
#write memory	Save config to startup config
#reload	Reload device after enabling evpn

PE1: LDP Configuration

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.1	Set the router ID to IP address 10.143.73.1.
(config-router)#transport-address ipv4 10.143.73.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)# targeted-peer ipv4 10.143.73.3	Configure targeted peer
(config-router-targeted-peer)# exit-targeted-peer-mode	Exit from router target peer and LDP mode

PE1: Interface Configuration Network Side

(config)#interface xe16	Enter the Interface mode for xe16
(config-if)# ip address 10.255.128.2/31	Configure IP address on the interface.
(config-if)#mtu 9900	Configure mtu at interface level
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# enable-ldp ipv4	Enable ldp on the interface.
(config-if)#exit	Exit interface mode

(config)#interface xe4	Enter the Interface mode for xe4.
(config-if)# ip address 10.255.128.10/31	Configure IP address on the interface.
(config-if)#mtu 9900	Configure mtu at interface level
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# enable-ldp ipv4	Enable ldp on the interface.
(config-if)#exit	Exit interface mode

PE1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.1	Router-id configurations
(config-router)# bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)# network 10.143.73.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.255.128.2/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 10.255.128.10/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# ospf segment-routing global block 16000 17000	Enable SRGB under ospf process 100
(config-router)#segment-routing mpls	Enable segment routing
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.

PE1: BGP Configuration

(config)# router bgp 100	Enter the Router BGP mode, ASN: 100.
(config-router)# neighbor 10.143.73.3 remote-as 100	Configuring PE3 as iBGP neighbor using it's loopback ip.
(config-router)# neighbor 10.143.73.3 fall-over bfd multihop	Configure neighbor bfd multihop
(config-router)# neighbor 10.143.73.3 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 10.143.73.3 advertisement-interval 0	Configure advertisement interval
(config-router)# address-family vpnv4 unicast	Enter VPNv4 Address family mode
(config-router-af)# neighbor 10.143.73.3 activate	Enabling VPNv4 Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.
(config-router)# address-family l2vpn vpls	Enter l2vpn Address family mode
(config-router-af)# neighbor 10.143.73.3 activate	Enabling l2vpn Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.
(config-router)# address-family l2vpn evpn	Enter evpn Address family mode
(config-router-af)# neighbor 10.143.73.3 activate	Enabling evpn Address family for neighbor..

(config-router-af)# exit-address-family	Exit Address-family mode.
(config-router)# address-family vpnv6 unicast	Enter VPNv6 Address family mode
(config-router-af)# neighbor 10.143.73.3 activate	Enabling VPNv6 Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.

PE1: SR policy Configuration

(config)#segment-routing	Enter the segment routing mode.
(config-sr)# mpls sr-prefer	prefer segment routing MPLS entries for forwarding.
((config-sr)#traffic-engineering	Enter traffic engineering mode.
(config-sr-te)# policy PE1-P1-PE3	Configure SR policy
(config-sr-pol)# color 1 end-point 10.143.73.3	Configure color with destination address.
(config-sr-pol)#candidate-path 1	Enter candidate path mode.
(config-sr-pol-cp)#dynamic-path ospf 100	Configure dynamic path ospf
(config-sr-pol-cp)#constraints	Enter constraint mode
(config-sr-dyn-cp-cons)# 10.143.73.5 loose	Configure P1 as next-hop loose mode.
(config-sr-dyn-cp-cons)#exit-pol-cp	Exit candidate path mode.
(config-sr-pol-cp)#exit-sr-pol	Exit SR policy mode.
(config-sr-te)# policy PE1-P2-PE3	Configure SR policy
(config-sr-pol)# color 2 end-point 10.143.73.3	Configure color with destination address.
(config-sr-pol)#candidate-path 1	Enter candidate path mode.
(config-sr-pol-cp)#dynamic-path ospf 100	Configure dynamic path ospf
(config-sr-pol-cp)#constraints	Enter constraint mode
(config-sr-dyn-cp-cons)# 10.143.73.6 loose	Configure P2 as next-hop loose mode.
(config-sr-dyn-cp-cons)#exit-pol-cp	Exit candidate path mode.
(config-sr-pol-cp)#exit-sr-pol	Exit SR policy mode.

PE1: Tunnel Policy Configuration

(config)# tunnel-policy PE1-P1-PE3	Configure tunnel policy
(config-tnl-policy)#color 1	Map the color with the SR policy to be used..
(config-tnl-policy)#exit	Exiting tunnel policy mode
(config)# tunnel-policy PE1-P2-PE3	Configure tunnel policy
(config-tnl-policy)#color 2	Map the color with the SR policy to be used..
(config-tnl-policy)#exit	Exiting tunnel policy mode

PE1: VPWS Configuration

(config)# mpls l2-circuit pe1-to-pe3 2002 10.143.73.3	Configure the VC for PE3. In this example, pe1-to-pe3 is the VC name, 2002 is the VC ID, and 10.143.73.3 is the VC endpoint IP address.
(config-pseudowire)# tunnel-select-policy PE1-P1-PE3	Configure Tunnel-Policy on VC pe1-to-pe3
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#exit	Exiting from config mode
(config)#service-template pe1-to-pe3	Template configuration.
(config-svc)# match outer-vlan 2002	Match criteria under template configuration
(config)#exit	Exiting from config mode

PE1: VPLS Configuration

(config)# mpls vpls vpls-pe1-to-pe3pe4-1 2502	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type ethernet	Type ethernet configuration for VPLS
(config-vpls-sig)# vpls-peer 10.143.73.3 tunnel-select-policy PE1-P2-PE3	Configure VPLS Peer with tunnel-policy
(config-vpls-sig)#exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#service-template vpls-pe1-to-pe3pe4-1	Template configuration.
(config-svc)# match outer-vlan 2502	Match criteria under template configuration
(config-svc)# rewrite ingress translate 2600 outgoing-tpid dot1.q	Action performed for service template.
(config)# mpls vpls vpls-pe1-to-pe3pe4-2 2503	Enter VPLS config mode
(config-vpls)#signaling bgp	Enter the Signaling bgp mode for BGP VPLS.
(config-vpls-sig)# ve-id 3	Configure VE ID, which is mandatory for BGP VPLS, otherwise, signaling does not take place. VE ID should be unique per VPLS instance
(config-vpls-sig)# tunnel-select-policy PE1-P1-PE3	Configure tunnel-policy for a VPLS instance
(config-vpls-sig)#exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#service-template vpls-pe1-to-pe3pe4-2	Template configuration.
(config-svc)# match double-tag outer-vlan 2503 inner-vlan 2504	Match criteria under template configuration
(config-svc)# rewrite ingress push 2505	Action performed for service template.

PE1: MAC VRF and IP VRF Configuration for EVPN and L3VPN services

Note: For EVPN Service, Tunnel Policy can be applied at mac vrf level and VNID level, When Configured at both levels, Preference is given to VNID level.

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)# tunnel-select-policy PE1-P1-PE3	Map tunnel policy to mac vrf
(config-vrf)#rd 10.143.73.1:2	Configuring Route-Distinguisher value 10.143.73.1:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2
(config-vrf)#exit	Exiting VRF Mode.
(config)#mac vrf elan500	Enter VRF mode
(config-vrf)#rd 10.143.73.1:500	Configuring Route-Distinguisher value 10.143.73.1:500
(config-vrf)#route-target both 500:500	Configuring import and export value as 500:500
(config)# ip vrf vrf600	Enter VRF mode
(config-vrf)# tunnel-select-policy PE1-P1-PE3	Configure tunnel-policy to be used for the VRF.
(config-vrf)# rd 10.143.73.1:600	Configuring Route-Distinguisher value 10.143.73.1:600
(config-vrf)#route-target both 600:600	Configuring import and export value as 600:600
(config-vrf)#exit	Exiting VRF Mode.

PE1: EVPN and MAC-VRF mapping for ELAN and ELINE

(config)#evpn mpls id 2 xconnect target-mpls-id 252	Configure the EVPN-ELINE identifier with source identifier 2 and target identifier 252.
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier.
(config-evpn-mpls)#exit	Exiting from evpn-mpls mode
(config)# evpn mpls id 500	Configure evpn mpls id 500
(config-evpn-mpls)#tunnel-select-policy PE1-P2-PE3	Map tunnel-policy to EVI
(config-evpn-mpls)#host-reachability-protocol evpn-bgp elan500	Mapping vrf " elan500" to EVPN-VPLS identifier.

PE1: Access side Configuration

(config)#interface xe8	Enter the Interface mode for xe8
(config-if)# switchport	Configure interface as switch port
(config-if)# mpls-l2-circuit pe1-to-pe3 service-template pe1-to-pe3 primary	Bind the interface to the VC with service template
(config-if)# mpls-vpls vpls-pe1-to-pe3pe4-1 service-template vpls-pe1-to-pe3pe4-1	Bind the VPLS instance to the interface
(config-if-vpls)# exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)# mpls-vpls vpls-pe1-to-pe3pe4-2 service-template vpls-pe1-to-pe3pe4-2	Bind the VPLS instance to the interface
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)# exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)# exit	Exit from the interface
(config)#interface xe8.2 switchport	Configure Interface xe8.2 as switchport

(config-if)#encapsulation dot1q 2	Setting Encapsulation to dot1q with VLAN ID 2
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration.
(config-access-if)#map vpn-id 2	Map vpn-id 2 to interface xe8.2 (VPWS).
(config-access-if)#exit	Exiting out of access interface mode.
(config)#interface xe8.500 switchport	Configure Interface xe8.500 as switchport
(config-if)#encapsulation dot1q 500	Setting Encapsulation to dot1q with VLAN ID 500
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration.
(config-access-if)#map vpn-id 500	Map vpn-id 500 to interface xe8.500 (VPLS).
(config-access-if)#exit	Exiting out of access interface mode.
(config)#interface xe8.600	Enter Interface mode xe8.600
(config-if)# ip vrf forwarding vrf600	Bind the VRF instance to the interface
(config-if)# ip address 170.1.1.1/24	Configure IP address
(config-if)# ipv6 address 1111::1/64	Configure ipv6 address
(config-if)#encapsulation dot1q 600	Setting Encapsulation to dot1q with VLAN ID 600
(config-if)#exit	Exiting interface Mode.
(config)# router bgp 100	Enter BGP router mode
(config-router)#address-family ipv4 vrf vrf600	Configure VRF address family
(config-router-af) redistribute connected	Redistribute connected router
(config-router-af)#neighbor 170.1.1.2 remote-as 200	Configure neighbor with remote-as
(config-router-af)#neighbor 170.1.1.2 activate	Activate the VPN neighbour
(config-router-af) exit-address-family	Exit VRF address family
(config-router)#address-family ipv6 vrf vrf600	Configure ipv6 VRF address family
(config-router-af) redistribute connected	Redistribute connected router
(config-router-af)#neighbor 1111::2 remote-as 200	Configure neighbor with remote-as
(config-router-af)#neighbor 1111::2 activate	Activate the VPN neighbour
(config-router-af) exit-address-family	Exit VRF address family
(config-router-af) exit	End
(config-router) #commit	Commit the candidate configuration to the running configuration

P1: Loopback Interface

(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.5/32 secondary	Configure IP address on loopback interface.
(config-if)#prefix-sid index 5	Configure prefix sid index value
(config-if)#exit	Exit interface mode

P1: Interface Configuration Network Side

(config)#interface xe15	Enter the Interface mode for xe15
(config-if)# ip address 10.255.128.3/31	Configure IP address on the interface.
(config-if)# mtu 9900	Configure mtu
(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe7	Enter the Interface mode for xe7.
(config-if)# ip address 10.255.128.23/31	Configure IP address on the interface.
(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

P1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.5	Router-id configurations
(config-router)# bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)# network 10.143.73.5/32 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 10.255.128.2/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 10.255.128.22/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# ospf segment-routing global block 16000 17000	Enable SRGB under ospf process 100
(config-router)#segment-routing mpls	Enable segment routing
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the candidate configuration to the running configuration

P2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.6/32 secondary	Configure IP address on loopback interface.
(config-if)#prefix-sid index 6	Configure prefix sid index value
(config-if)#exit	Exit interface mode

P2: Interface Configuration Network Side

(config)#interface xe4	Enter the Interface mode for xe4
(config-if)# ip address 10.255.128.11/31	Configure IP address on the interface.
(config-if)# mtu 9900	Configure mtu

(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter the Interface mode for xe5.
(config-if)# ip address 10.255.128.25/31	Configure IP address on the interface.
(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

P2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.6	Router-id configurations
(config-router)# bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)# network 10.143.73.6/32 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 10.255.128.10/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# ospf segment-routing global block 16000 17000	Enable SRGB under ospf process 100
(config-router)#segment-routing mpls	Enable segment routing
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the candidate configuration to the running configuration

PE3: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 10.143.73.3/32 secondary	Configure IP address on loopback interface.
(config-if)#prefix-sid index 3	Configure prefix sid index value
(config-if)#exit	Exit interface mode

PE3: Global EVPN MPLS Command

#configure terminal	Enter configuration mode.
(config)#evpn mpls enable	Enable EVPN MPLS. Note: Reload is required after Enabling/Disabling EVPN MPLS Feature.
(config)#evpn mpls vtep-ip-global 10.143.73.3	Configuring vtep global ip to loopback IP.
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	End configuration mode

#write memory	Saving configs to startup config
#reload	Reload device after enabling evpn

PE3: LDP Configuration

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.3	Set the router ID to IP address 10.143.73.3.
(config-router)#transport-address ipv4 10.143.73.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)# targeted-peer ipv4 10.143.73.1	Configure targeted peer
(config-router-targeted-peer)# exit-targeted-peer-mode	Exit from router target peer and LDP mode

PE3: Interface Configuration Network Side

(config)#interface xe5	Enter the Interface mode for xe5
(config-if)# ip address 10.255.128.24/31	Configure IP address on the interface.
(config-if)#mtu 9900	Configure mtu at interface level
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# enable-ldp ipv4	Enable ldp on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe7	Enter the Interface mode for xe7.
(config-if)# ip address 10.255.128.22/31	Configure IP address on the interface.
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# enable-ldp ipv4	Enable ldp on the interface.
(config-if)#exit	Exit interface mode

PE3: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.3	Router-id configurations
(config-router)# bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)# network 10.143.73.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.255.128.22/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# ospf segment-routing global block 16000 17000	Enable SRGB under ospf process 100
(config-router)#segment-routing mpls	Enable segment routing
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.

PE3: BGP Configuration

(config)# router bgp 100	Enter the Router BGP mode, ASN: 100.
(config-router)# neighbor 10.143.73.1 remote-as 100	Configuring PE3 as iBGP neighbor using it's loopback ip.
(config-router)# neighbor 10.143.73.1 fall-over bfd multihop	Configure neighbor bfd multihop
(config-router)# neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 10.143.73.1 advertisement-interval 0	Configure advertisement interval
(config-router)# address-family vpnv4 unicast	Enter VPNv4 Address family mode
(config-router-af)# neighbor 10.143.73.1 activate	Enabling VPNv4 Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.
(config-router)# address-family l2vpn vpls	Enter l2vpn Address family mode
(config-router-af)# neighbor 10.143.73.1 activate	Enabling l2vpn Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.
(config-router)# address-family l2vpn evpn	Enter evpn Address family mode
(config-router-af)# neighbor 10.143.73.1 activate	Enabling evpn Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.
(config-router)# address-family vpnv6 unicast	Enter VPNv6 Address family mode
(config-router-af)# neighbor 10.143.73.1 activate	Enabling VPNv6 Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.

PE3: VPWS Configuration

(config)# mpls l2-circuit pe3-to-pe1 2002 10.143.73.1	Configure the VC for PE-1. In this example, pe3-to-pe1 is the VC name, 2002 is the VC ID, and 10.143.73.1 is the VC endpoint IP address.
(config)#exit	Exiting from config mode
(config)#service-template pe3-to-pe1	Template configuration.
(config-svc)# match outer-vlan 2002	Match criteria under template configuration
(config)#exit	Exiting from config mode

PE3: VPLS Configuration

(config)# mpls vpls vpls-pe3-to-pe1pe4-1 2502	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type Ethernet	Type ethernet configuration for VPLS
(config-vpls-sig)# vpls-peer 10.143.73.1	Configure VPLS Peer

(config-vpls-sig)#exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#service-template vpls-pe3-to-pe4-1	Template configuration.
(config-svc)# match outer-vlan 2502	Match criteria under template configuration
(config-svc)# rewrite ingress translate 2600 outgoing-tpid dot1.q	Action performed for service template.
(config)# mpls vpls vpls-pe3-to-pe4-2 2503	Enter VPLS config mode
(config-vpls)#signaling bgp	Enter the Signaling bgp mode for BGP VPLS.
(config-vpls-sig)# ve-id 4	Configure VE ID, which is mandatory for BGP VPLS, otherwise, signaling does not take place. VE ID should be unique per VPLS instance
(config-vpls-sig)#exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#service-template vpls-pe3-to-pe4-2	Template configuration.
(config-svc)# match double-tag outer-vlan 2503 inner-vlan 2504	Match criteria under template configuration
(config-svc)# rewrite ingress push 2505	Action performed for service template.

PE3: MAC and IP VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.3:2	Configuring Route-Distinguisher value 10.143.73.3:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2
(config-vrf)#exit	Exiting VRF Mode.
(config)#mac vrf elan500	Enter VRF mode
(config-vrf)#rd 10.143.73.3:500	Configuring Route-Distinguisher value 10.143.73.3:500
(config-vrf)#route-target both 500:500	Configuring import and export value as 500:500
(config)# ip vrf vrf600	Enter VRF mode
(config-vrf)# rd 10.143.73.3:600	Configuring Route-Distinguisher value 10.143.73.3:600
(config-vrf)#route-target both 600:600	Configuring import and export value as 600:600
(config-vrf)#exit	Exiting VRF Mode.

PE3: EVPN and mac vrf mapping Configuration

(config)#evpn mpls id 252 xconnect target-mpls-id 2	Configure the EVPN-ELINE identifier with source identifier 252 and target identifier 2.
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier.
(config-evpn-mpls)#exit	Exiting from evpn-mpls mode
(config)# evpn mpls id 500	Configure evpn mpls id 500
(config-evpn-mpls)#host-reachability-protocol evpn-bgp elan500	Mapping vrf " elan500" to EVPN-VPLS identifier.

PE3: Access side Configuration

(config)#interface xe4	Enter the Interface mode for xe8
(config-if)# switchport	Configure interface as switch port
(config-if)# mpls-l2-circuit pe3-to-pe1 service-template pe3-to-pe1 primary	Bind the VPWS instance to the interface
(config-if)# mpls-vpls vpls-pe3-to-pe1pe4-1 service-template vpls-pe3-to-pe1pe4-1	Bind the VPLS instance to the interface
(config-if-vpls)# exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)# mpls-vpls vpls-pe3-to-pe1pe4-2 service-template vpls-pe3-to-pe1pe4-2	Bind the VPLS instance to the interface
(config-if-vpls)# exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)# exit	Exit from the interface
(config)#interface xe4.2 switchport	Configure Interface xe4.2 as switchport
(config-if)#encapsulation dot1q 2	Setting Encapsulation to dot1q with VLAN ID 2
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration.
(config-access-if)#map vpn-id 252	Map vpn-id 252 to interface xe4.2 (VPWS).
(config-access-if)#exit	Exiting out of access interface mode.
(config)#interface xe4.500 switchport	Configure Interface xe4.500 as switchport
(config-if)#encapsulation dot1q 500	Setting Encapsulation to dot1q with VLAN ID 500
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration.
(config-access-if)#map vpn-id 500	Map vpn-id 500 to interface xe4.500 (VPLS).
(config-access-if)#exit	Exiting out of access interface mode.
(config)#interface xe4.600	Enter Interface mode xe4.600
(config-if)# ip vrf forwarding vrf600	Bind the VRF instance to the interface
(config-if)# ip address 180.1.1.1/24	Configure IP address
(config-if)# ipv6 address 2222::1/64	Configure ipv6 address
(config-if)#encapsulation dot1q 600	Setting Encapsulation to dot1q with VLAN ID 600
(config-if)#exit	Exiting interface Mode.
(config)# router bgp 100	Enter BGP router mode
(config-router)#address-family ipv4 vrf vrf600	Configure VRF address family
(config-router-af) redistribute connected	Redistribute connected router
(config-router-af)#neighbor 180.1.1.2 remote-as 300	Configure neighbor with remote-as
(config-router-af)#neighbor 180.1.1.2 activate	Activate the VPN neighbour
(config-router-af)exit-address-family	Exit VRF address family
(config-router)#address-family ipv6 vrf vrf600	Configure ipv6 VRF address family
(config-router-af) redistribute connected	Redistribute connected router
(config-router-af)#neighbor 2222::2 remote- as 300	Configure neighbor with remote-as
(config-router-af)#neighbor 2222::2 activate	Activate the VPN neighbour

(config-router-af)exit-address-family	Exit VRF address family
(config-router-af)end	End
(config)#commit	Commit the candidate configuration to the running configuration

Validation

CLI's : Show segment-routing policy, show tunnel-policy, show tunnel-policy service details, show mpls forwarding-table

PE1

PE1#show segment-routing policy

Policy-Name	Color	End-point	State	Forwarding-Info
PE1-P1-PE3	1	10.143.73.3	UP	3/16003/xe16
PE1-P2-PE3	2	10.143.73.3	UP	3/16003/xe4

VPWS

PE1#show mpls vc-table

VC-ID	Vlan-ID	Inner-Vlan-ID	Access-Intf	Network-Intf	Out Label	Tunnel-Label	Nexthop	Status
2002	N/A	N/A	xe8	xe16	25600	3	10.143.73.3	Active

PE1#show mpls l2-circuit

MPLS Layer-2 Virtual Circuit: pe1-to-pe3, id: 2002 PW-INDEX: 2 service-tpid: dot1.q
Tunnel-Policy: PE1-P1-PE3 >>> VPWS is up by using Applied Tunnel Policy
Endpoint: 10.143.73.3
Control Word: 0
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe8
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : pe1-to-pe3
Match criteria : 2002

VPLS

PE1#show mpls vpls mesh

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX	SIG-Protocol	Status
2502	10.143.73.3	3	26241	xe4	25601	2/Up	1	LDP	Active
2503	10.143.73.3	3	25604	xe16	24962	2/Up	3	BGP	Active

PE1#show mpls vpls detail

Virtual Private LAN Service Instance: vpls-pe1-to-pe3pe4-1, ID: 2502

SIG-Protocol: LDP
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
Interface: xe8
Service-template : vpls-pe1-to-pe3pe4-1
Match criteria : 2502
Action type : Translate
Action value : 2600
Outgoing tpid : dot1.q

Mesh Peers:

10.143.73.3 (Up)
Tunnel-Policy: PE1-P2-PE3 >>> VPLS-LDP is up using applied tunnel policy

```

Virtual Private LAN Service Instance: vpls-pe1-to-pe3pe4-2, ID: 2503
SIG-Protocol: BGP
Route-Distinguisher :100:2503
Route-Target :100:2503
VE-ID :3
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Group ID: 0, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
  Interface: xe8
Service-template : vpls-pe1-to-pe3pe4-2
Match criteria : 2503/2504
Action type : Push
Action value : 2505

Mesh Peers:
  10.143.73.3 (Up)
  Tunnel-Policy: PE1-P1-PE3 VPLS-BGP is up using applied tunnel policy

```

EVPN E-LAN

```

PE1#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
(*) in Policy - tunnel-policy inherited from mac-vrf
Destination      Status      evpn-id  Policy      Network-Intf Tunnel-Label MC-
  Local          Remote
Label UC-Label MC-Label UC-Label
=====
10.143.73.3      Installed  500      PE1-P2-PE3   xe4          3          640      17      640      --
Total number of entries are 1

```

Here Tunnel Policy is applied under VNID level.

EVPN E-LINE

```

PE1#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
(*) in Policy - tunnel-policy inherited from mac-vrf
Destination      Status      Local      Remote
  Local          Remote    VPWS-ID    VPWS-ID    Policy      Network-Intf Tunnel-
Label MC-Label UC-Label MC-Label UC-Label
=====
10.143.73.3      Installed  2          252        PE1-P1-PE3(*) xe16        3          --      16      --      16

```

Total number of entries are 1

Here Tunnel Policy is applied under mac-vrf level.

L3VPN and 6VPE

```

PE1#show mpls vrf-table
Output for IPv4 VRF table with id: 4
Primary FTN entry with FEC: 180.1.1.0/24, id: 1, row status: Active, Tunnel-Policy: PE1-P1-PE3
Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Transport Tunnel id: 1, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, Color: 1
  Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 8
    Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 8, owner: BGP, Stale: NO, BGP out intf: xe16, transport out intf: xe16, out label: 25024
  Nexthop addr: 10.143.73.3      cross connect ix: 6, op code: Push and Lookup

```

```

Output for IPv6 VRF table with id: 4
Primary FTN entry with FEC: 2222::/64, id: 13, row status: Active, Tunnel-Policy: PE1-P1-PE3
Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Transport Tunnel id: 1, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, Color: 1
  Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 8
    Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up

```


Out-segment with ix: 8, owner: BGP, Stale: NO, BGP out intf: xe16, transport out intf: xe16, out label: 25024
 Nexthop addr: 10.143.73.3 cross connect ix: 6, op code: Push and Lookup

PE1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
P>	10.143.73.3/32	4	10	1	Yes	LSP_DEFAULT	3	xe16	No	10.255.128.3
P>	10.143.73.3/32	5	11	2	Yes	LSP_DEFAULT	3	xe4	No	10.255.128.11
O	10.143.73.3/32	1	3	0	Yes	LSP_DEFAULT	16003	xe16	No	10.255.128.3
O>	10.143.73.5/32	2	5	0	Yes	LSP_DEFAULT	3	xe16	No	10.255.128.3
O>	10.143.73.6/32	3	6	0	Yes	LSP_DEFAULT	3	xe4	No	10.255.128.11

PE1#show mpls forwarding-table detail

FEC prefix: 10.143.73.3/32, FTN-ID: 4
 Owner: SR_POLICY, FTN type: Regular, State: Installed
 Tunnel-Name: N/A, Tunnel-id: 1, Color: 1
 LSP-ID: N/A, LSP-type: Primary
 NHLFE-id: 10
 Out-Label: 3, Out-Intf: xe16, Nexthop: 10.255.128.3
 Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
 ELC: No

FEC prefix: 10.143.73.3/32, FTN-ID: 5
 Owner: SR_POLICY, FTN type: Regular, State: Installed
 Tunnel-Name: N/A, Tunnel-id: 2, Color: 2
 LSP-ID: N/A, LSP-type: Primary
 NHLFE-id: 11
 Out-Label: 3, Out-Intf: xe4, Nexthop: 10.255.128.11
 Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
 ELC: No

FEC prefix: 10.143.73.3/32, FTN-ID: 1
 Owner: OSPF-SR, FTN type: Regular, State: Not Selected
 Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
 LSP-ID: N/A, LSP-type: Primary
 NHLFE-id: 3
 Out-Label: 16003, Out-Intf: xe16, Nexthop: 10.255.128.3
 Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
 ELC: No

FEC prefix: 10.143.73.5/32, FTN-ID: 2
 Owner: OSPF-SR, FTN type: Regular, State: Installed
 Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
 LSP-ID: N/A, LSP-type: Primary
 NHLFE-id: 5
 Out-Label: 3, Out-Intf: xe16, Nexthop: 10.255.128.3
 Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
 ELC: No

FEC prefix: 10.143.73.6/32, FTN-ID: 3
 Owner: OSPF-SR, FTN type: Regular, State: Installed
 Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
 LSP-ID: N/A, LSP-type: Primary
 NHLFE-id: 6
 Out-Label: 3, Out-Intf: xe4, Nexthop: 10.255.128.11
 Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
 ELC: No

Tunnel policy Output after applying under all services

PE1#show tunnel-policy
 tunnel-policy PE1-P1-PE3
 color 1
 tunnel-mode dedicated
 tunnel-type any
 Total Services attached:
 VRF : 1
 VPWS : 1

```

VPLS      : 1
EVPN      : 1

tunnel-policy PE1-P2-PE3
  color 2
  tunnel-mode dedicated
  tunnel-type any
Total Services attached:
  VRF      : 0
  VPWS     : 0
  VPLS     : 1
  EVPN     : 1

PE1#show tunnel-policy service details
List of services configured with tunnel-policy PE1-P1-PE3:
  VPWS
    VPWS-Id: 2002, Name: pe1-to-pe3 Status: UP, Mapped Tunnel: SR_POLICY, ftn_ix 4, color 1
  L3VPN
    VRF id 4
      FTN id: 1, Prefix: 180.1.1.0/24, Status: Up, Label: 25024, Mapped Tunnel: SR_POLICY, ftn_ix 4, color 1
      FTN id: 13, Prefix: 2222::/64, Status: Up, Label: 25024, Mapped Tunnel: SR_POLICY, ftn_ix 4, color 1
  VPLS
    VPLS-Id: 2503, Name: vpls-pe1-to-pe3pe4-2, Status: UP, Mapped Tunnel: SR_POLICY, ftn_ix 4, color 1
  EVPN
    EVPN-Id: 2, Tunnel count: 1
    Peer: 10.143.73.3, Mapped Tunnel: SR_POLICY, ftn_ix 4, color 1
List of services configured with tunnel-policy PE1-P2-PE3:
  VPLS
    VPLS-Id: 2502, Name: vpls-pe1-to-pe3pe4-1, Status: UP, Mapped Tunnel: SR_POLICY, ftn_ix 5, color 2
  EVPN
    EVPN-Id: 500, Tunnel count: 1
    Peer: 10.143.73.3, Mapped Tunnel: SR_POLICY, ftn_ix 5, color 2

```

PE2 Validation:

```

PE2#show mpls vc-table
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label Tunnel-Label Nexthop Status
2002 N/A N/A xe22 xe7 26880 16001 10.143.73.1 Active

PE2#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: pe3-to-pe1, id: 2002 PW-INDEX: 2 service-tpid: dot1.q
Endpoint: 10.143.73.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe4
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : pe3-to-pe1
Match criteria : 2002

PE2#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID Peer Addr Tunnel-Label In-Label Network-Intf Out-Label Lkps/St PW-INDEX SIG-Protocol Status
2502 10.143.73.1 16001 26881 xe7 26881 2/Up 1 LDP Active
2503 10.143.73.1 16001 25602 xe7 25603 2/Up 3 BGP Active

PE2#show mpls vpls detail
Virtual Private LAN Service Instance: vpls-pe3-to-pe1pe4-1, ID: 2502
SIG-Protocol: LDP
Attachment-Circuit :UP

```

```
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
Interface: xe4
Service-template : vpls-pe3-to-pe4-1
Match criteria : 2502
Action type : Translate
Action value : 2600
Outgoing tpid : dot1.q

Mesh Peers:
10.143.73.1 (Up)
Virtual Private LAN Service Instance: vpls-pe3-to-pe4-2, ID: 2503
```

```
SIG-Protocol: BGP
Route-Distinguisher :100:2503
Route-Target :100:2503
VE-ID :4
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
Interface: xe4
Service-template : vpls-pe3-to-pe4-2
Match criteria : 2503/2504
Action type : Push
Action value : 2505
```

```
Mesh Peers:
10.143.73.1 (Up)
```

```
PE2#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
(*) in Policy - tunnel-policy inherited from mac-vrf
(e) - Service mapped over MPLS Multipath/ECMP
=====
Local Remote MPLS-Multipath Underlay
Destination Status VPN-ID Policy MC-Label UC-Label MC-Label UC-Label Grp-Name NHLFE-ix NW-Intf NW-Label
=====
10.143.73.1 Installed 500 -- 640 17 640 -- -- -- xe7 16001
Total number of entries are 1
```

```
PE2#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
(*) in Policy - tunnel-policy inherited from mac-vrf
(e) - Service mapped over MPLS Multipath/ECMP
=====
Local Remote Local Remote MPLS-Multipath Underlay
Destination Status VPWS-ID VPWS-ID Policy UC-Label UC-Label Grp-Name NHLFE-ix NW-Intf NW-Label
=====
10.143.73.1 Installed 252 2 -- 16 16 -- -- -- xe7 16001
Total number of entries are 1
PE2#show mpls vrf-table
Output for IPv4 VRF table with id: 4
Primary FTN entry with FEC: 170.1.1.0/24, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
VRF id 4, BGP peer 10.143.73.1 BGP prefix 170.1.1.0
Transport Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, , Color: 0
```

```
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 5

Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: BGP, Stale: NO, BGP out intf: xe7, transport out intf: xe7, out label: 25664
Nexthop addr: 10.143.73.1 cross connect ix: 4, op code: Push and Lookup

Output for IPv6 VRF table with id: 4
Primary FTN entry with FEC: 1111::/64, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
VRF id 4, BGP peer a8f:4901:: BGP prefix 1111::
Transport Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 5
Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: BGP, Stale: NO, BGP out intf: xe7, transport out intf: xe7, out label: 25664
Nexthop addr: 10.143.73.1 cross connect ix: 4, op code: Push and Lookup

PE2#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport, (e) - FTN is ECMP
Code FEC FTN-ID Nhlfe-ID Tunnel-id Pri LSP-Type Out-Label Out-Intf ELC Nexthop
O> 10.143.73.1/32 1 9 0 Yes LSP_DEFAULT 16001 xe7 No 10.255.128.23
O> 10.143.73.5/32 2 10 0 Yes LSP_DEFAULT 3 xe7 No 10.255.128.23
O> 10.143.73.6/32 3 14 0 Yes LSP_DEFAULT 3 xe5 No 10.255.128.25
PE2#show mpls forwarding-table detail
FEC prefix: 10.143.73.1/32, FTN-ID: 1
Owner: OSPF-SR, FTN type: Regular, State: Installed
Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
LSP-ID: N/A, LSP-type: Primary
NHLFE-id: 9
Out-Label: 16001, Out-Intf: xe7, Nexthop: 10.255.128.23
Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
ELC: No
FEC prefix: 10.143.73.5/32, FTN-ID: 2
Owner: OSPF-SR, FTN type: Regular, State: Installed
Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
LSP-ID: N/A, LSP-type: Primary
NHLFE-id: 10
Out-Label: 3, Out-Intf: xe7, Nexthop: 10.255.128.23
Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
ELC: No
FEC prefix: 10.143.73.6/32, FTN-ID: 3
Owner: OSPF-SR, FTN type: Regular, State: Installed
Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
LSP-ID: N/A, LSP-type: Primary
NHLFE-id: 14
Out-Label: 3, Out-Intf: xe5, Nexthop: 10.255.128.25
Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
```

Note: The following CLI will be used to change from dedicated mode to best effort

```
tunnel-policy PE1-P1-PE3
color 1
mode best-effort
```

CHAPTER 16 Mapping RSVP Tunnel Name to L2VPN Service

This chapter shows configurations of mapping of rsvp tunnel-name to L2VPN service.

An MPLS Layer 2 Virtual Circuit (VC) is a point-to-point Layer 2 connection transported via MPLS on the service provider's network. The Layer 2 circuit is transported over a single Label Switched Path (LSP) tunnel between two Provider Edge (PE) routers

Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint-to-multipoint communication over IP-MPLS networks. It allows geographically-dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires. A set of Martini circuits is grouped by a common VPLS identifier to achieve this service objective

Overview

This topology will be applicable for both VPWS and VPLS services.

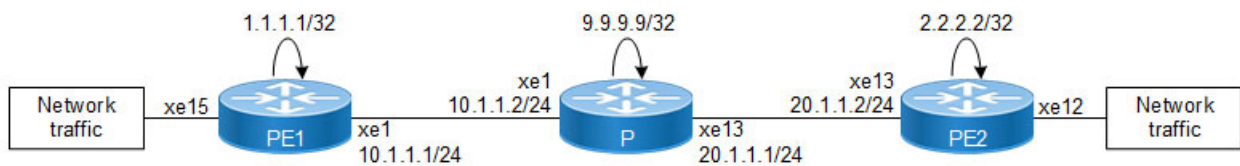


Figure 16-7: Mapping of RSVP Tunnel-name to L2VPN services

Configuring the VC:

Note: Loopback addresses being used should be advertised through OSPF, or should be statically routed.

1. Configure the IP address and OSPF for the PE1, P (Provider), and PE2 routers.
2. Configure MPLS and LDP on PE1, P, and PE2, and LDP targeted peer for the PE1 and PE2 routers. (If RSVP is used for configuring trunks, LDP must be configured on PE1 and PE2, and RSVP must be configured on PE1, P, and PE2).
3. Configure the VC with trunk-name.
4. Bind the customer interface to the VC.

Configure IP Address and OSPF on Routers

Configure the IP addresses and OSPF on the PE1, P, and PE2 routers.

PE1

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback interface (lo0) to be configured.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.

(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#ip address 10.1.1.1/24	Set the IP address of the interface to 10.1.1.1/24.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 1.1.1.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

P

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback interface (lo0) to be configured.
(config-if)#ip address 9.9.9.9/32 secondary	Set the IP address of the loopback interface to 9.9.9.9/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#ip address 10.1.1.2/24	Set the IP address of the interface to 10.1.1.2/24.
(config-if)#exit	Exit interface mode.
(config)#interface xe13	Specify the interface (xe13) to be configured.
(config-if)#label-switching	Enable label switching on interface xe13.
(config-if)#ip address 20.1.1.1/24	Set the IP address of the interface to 20.1.1.1/24.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 20.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 9.9.9.9/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback interface (lo0) to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe13	Specify the interface (xe13) to be configured.
(config-if)#label-switching	Enable label switching on interface xe13.

(config-if)#ip address 20.1.1.2/24	Set the IP address of the interface to 20.1.1.2/24.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 20.1.1.0/24 area 0	Define the interface on which OSPF runs, and associate the area ID (0) with the interface.
(config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs, and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

Configure MPLS, RSVP, and LDP Targeted Peer on Routers

Configure MPLS and LDP on PE1, P, and PE2, and LDP targeted peers on PE1 and PE2.

Note: If RSVP is used for configuring trunks, LDP must be configured on PE1 and PE2, and RSVP must be configured on PE1, P, and PE2.

PE1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config-router)#router-id 1.1.1.1	Configure the router-id
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 2.2.2.2	Specify the targeted LDP peer on PE1.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the Router mode.
(config)#router rsvp	Enter RSVP configuration mode for the router.
(config-router)#exit	Exit configuration mode of the router.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#exit	Exit interface mode.
(config)#rsvp-trunk t2	Configure RSVP trunk t2
(config-trunk)#to 2.2.2.2	Configure PE2 as the end of trunk
(config-trunk)#commit	Commit the transaction.

P

#configure terminal	Enter configure mode.
(config)#router rsvp	Enter RSVP configuration mode for the router.
(config)#exit	Exit configuration mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.

(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe13	Specify the interface (xe13) to be configured.
(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#exit	Exit interface mode.
(config)#rsvp-trunk t5	Configure RSVP trunk t5
(config-trunk)#to 2.2.2.2	Configure PE2 as the end of trunk
(config-trunk)#exit	Exit configuration mode
(config)#rsvp-trunk t6	Configure RSVP trunk t6
(config-trunk)#to 1.1.1.1	Configure PE2 as the end of trunk
(config-trunk)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config-router)#router-id 2.2.2.2	Configure the router-id
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 1.1.1.1	Specify the targeted LDP peer on PE2.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the Router mode.
(config)#router rsvp	Enter RSVP configuration mode for the router.
(config-router)#exit	Exit configuration mode of the router.
(config)#interface xe13	Specify the interface(xe13) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe13.
(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#exit	Exit interface mode.
(config)#rsvp-trunk t3	Configure RSVP trunk t3
(config-trunk)#to 1.1.1.1	Configure PE1 as the end of trunk
(config-trunk)#commit	Commit the transaction.

Configure VC

Configure the VC. Each VC ID uniquely identifies the Layer-2 circuit among all the Layer-2 circuits.

Note: Both PE routers (endpoints) must be configured with the same VC-ID (100 in this example).

PE1

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t2 100 2.2.2.2	Configure the VC for PE2. In this example, t2 is the VC name, 200 is the VC ID, and 2.2.2.2 is the VC endpoint IP address

(config-pseudowire)#tunnel-name t2	Configure the RSVP Trunk name as t2
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#mpls l2-circuit t3 300 2.2.2.2 mode raw	Configure the VC for PE2. In this example, t3 is the VC-name, 300 is the VC ID and 2.2.2.2 is the VC endpoint IP address
(config-pseudowire)#tunnel-name t2	Configure RSVP Trunk name as t2
(config-pseudowire)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t2 100 1.1.1.1	Configure the VC for PE1. In this example, t2 is the VC name, 200 is the VC ID, and 1.1.1.1 is the VC endpoint IP address
(config-pseudowire)#tunnel-name t3	Configure RSVP Tunnel name as t3
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#mpls l2-circuit t2 100 1.1.1.1	Configure the VC for PE1. In this example, t2 is the VC name, 200 is the VC ID, and 1.1.1.1 is the VC endpoint IP address using rsvp trunk name t2
(config-pseudowire)#tunnel-name t3	Configure RSVP Tunnel name as t2
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#mpls l2-circuit t3 300 1.1.1.1 mode raw	Configure the VC for PE1. In this example, t3 is the VC name, 300 is the VC ID, and 1.1.1.1 is the VC endpoint IP address
(config-pseudowire)#tunnel-name t3	Configure RSVP Tunnel name as t3
(config-pseudowire)#commit	Commit the transaction.

Bind Customer Interface to VC

The following configuration allows only VLAN 2 and 3 traffic.

PE1

(config)#service-template ST1	Create a service template ST1
(config-svc)#match outer-vlan 2	Allow VLAN 2 traffic on this VC.
(config-svc)#exit	Exit the service template mode
(config)#service-template ST2	Create a service template ST2
(config-svc)#match outer-vlan 3	Allow VLAN 3 traffic on this VC.
(config-svc)#exit	Exit the service template mode
(config)#interface xe15	Specify the interface (xe15) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#mpls-l2-circuit t2 service-template ST1	Bind the interface to the VC with service template.
(config-if)#mpls-l2-circuit t3 service-template ST2	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.

PE2

(config)#service-template ST1	Create a service template ST1
(config-svc)#match outer-vlan 2	Allow VLAN 2 traffic on this VC.
(config-svc)#exit	Exit the service template mode
(config)#service-template ST2	Create a service template ST2
(config-svc)#match outer-vlan 3	Allow VLAN 3 traffic on this VC.
(config-svc)#exit	Exit the service template mode
(config)#interface xe12	Specify the interface (xe12) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#mpls-l2-circuit t2 service-template ST1	Bind the interface to the VC with service template.
(config-if)#mpls-l2-circuit t3 service-template ST2	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.

Validation

Use the show ldp mpls-l2-circuit (Control Plane) command, and the show mpls vc-table (Forwarding Plane) command, to display complete information about the Layer 2 VC.

If the VC State is UP in the output from the show ldp mpls-l2 circuit command, and the Status is Active in the output of the show mpls vc-table command, a ping from CE1 to CE2 should be successful.

Below are the sample output for VPWS service with Tunnel name:

```
PE1#show mpls vc-table
VC-ID      Vlan-ID    Inner-Vlan-ID  Access-Intf   Network-Intf   Out Label   Tunnel-Label   Nexthop       Status
100        N/A        N/A            xe15          xe1            24320       24321         2.2.2.2       Active
300        N/A        N/A            xe15          xe1            24321       24321         2.2.2.2       Active
PE1#
```

```
PE1#show ldp mpls-l2-circuit
Transport   Client      VC          VC           Local        Remote       Destination
VC ID       Binding     State      Type          VC Label     VC Label     Address
300         xe15        UP         Ethernet      24321        24321        2.2.2.2
100         xe15        UP         Ethernet VLAN 24320    24320        2.2.2.2
PE1#
```

```
PE1#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: t2, id: 100 PW-INDEX: 1 Tunnel-Name: t2
Endpoint: 2.2.2.2
Control Word: 0
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe15
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST1
Match criteria : 2
```

```
MPLS Layer-2 Virtual Circuit: t3, id: 300 PW-INDEX: 2 Tunnel-Name: t2
Operating mode: Raw
Endpoint: 2.2.2.2
Control Word: 0
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe15
Virtual Circuit Type: Ethernet
```

```
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST2
Match criteria : 3
```

```
PE1#show ldp mpls-l2-circuit detail
PW ID: 300, VC state is up
Access IF: xe5,up,AC state is up
Session IF: xe2, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: ethernet, remote vctype :ethernet
Local groupid: 0, remote groupid: 0
Local label: 26881, remote label: 53760
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:02:12
```

```
PW ID: 100, VC state is up
Access IF: xe5,up,AC state is up
Session IF: xe2, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26880, remote label: 53761
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:02:12
```

PE2

```
PE2#sh mpls vc-table
VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label Tunnel-Label Nexthop Status
100 N/A N/A xe12 xe3 26880 25600 1.1.1.1 Active
300 N/A N/A xe12 xe3 26881 25600 1.1.1.1 Active
PE2#sh ldp mpls-l2-circuit
Transport Client VC VC Local Remote Destination
VC ID Binding State Type VC Label VC Label Address
300 xe12 UP Ethernet 53760 26881 1.1.1.1
100 xe12 UP Ethernet VLAN 53761 26880 1.1.1.1
```

```
PE2#sh mpls l2-circuit
MPLS Layer-2 Virtual Circuit: t2, id: 100 PW-INDEX: 1 service-tpid: dot1.q
Tunnel-Name: t3
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST1
Match criteria : 2
```

```
MPLS Layer-2 Virtual Circuit: t3, id: 300 PW-INDEX: 2 service-tpid: dot1.q
Tunnel-Name: t3
```

```
Operating mode: Raw
```

```
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST2
Match criteria : 3
```

```
PE2#show ldp mpls-l2-circuit detail
PW ID: 300, VC state is up
Access IF: xe12,up,AC state is up
Session IF: xe3, state is up
Destination: 1.1.1.1, Peer LDP Ident: 1.1.1.1
Local vctype: ethernet, remote vctype :ethernet
Local groupid: 0, remote groupid: 0
Local label: 53760, remote label: 26881
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:05:34
```

```
PW ID: 100, VC state is up
Access IF: xe12,up,AC state is up
Session IF: xe3, state is up
Destination: 1.1.1.1, Peer LDP Ident: 1.1.1.1
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 53761, remote label: 26880
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:05:34
```

These additional commands can also be used to display information about the Layer 2 virtual circuits.

```
show ldp mpls-l2-circuit detail
show ldp mpls-l2-circuit VC-ID
show ldp mpls-l2-circuit VC-ID detail
show mpls l2-circuit
```

Configuring a MPLS Static Layer-2 VC

1. Configure the VC with the manual option using tunnel name
2. Configure the VC FIB entry.
3. Bind the VC; all steps are in the configurations that follow.

PE1

#configure terminal	Enter configure mode.
PE1(config)#mpls l2-circuit t5 500 2.2.2.2	Configure the VC for PE1
PE1(config-pseudowire)#tunnel-name t2	Configure the RSVP Tunnel name as t2
PE1(config-pseudowire)#manual-pseudowire	Configure the VC as manual (no signaling is used)
PE1(config-pseudowire)#exit	Exit pseudowire config mode.
PE1(config)#service-template ST5	Create a service template ST5
PE1(config-svc)#match outer-vlan 5	Configure single match criteria vlan 5
PE1(config-svc)#exit	Exit the service template mode
PE1(config)#interface xe15	Access interface xe15
(config-if)#switchport	Switch to Layer-2 mode.
PE1(config-if)#mpls-l2-circuit t5 service-template ST5	Bind the interface to the VC with service template.
PE1(config-if)#exit	Exit interface mode
PE1(config-if)#commit	Commit the transaction.
PE1(config)#mpls l2-circuit-fib-entry 500 1000 2000 2.2.2.2 xe1 xe15	Add an FTN entry; where 1000 is the incoming label, 2000 is the outgoing label, 2.2.2.2 is the endpoint, xe1 is the Provider facing interface name, and xe15 is access interface name
PE1(config)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
PE2(config)#mpls l2-circuit t5 500 1.1.1.1	Configure the VC for PE2
PE2(config-pseudowire)#tunnel-name t3	Configure RSVP Tunnel name as t3
PE2(config-pseudowire)#manual-pseudowire	Configure VC as manual (no signaling used)
PE2(config-pseudowire)#exit	Exit pseudowire config mode.
PE2(config)#service-template ST5	Create a service template ST5
PE2(config-svc)#match outer-vlan 5	Configure single match criteria vlan 5
PE2(config-svc)#exit	Exit the service template mode
PE2(config)#interface xe12	Access interface xe12
(config-if)#switchport	Switch to Layer-2 mode.
PE2(config-if)#mpls-l2-circuit t5 service-template ST5	Bind the interface to the VC with service template.
PE2(config-if)#exit	Exit interface mode.
PE2(config-if)#commit	Commit the transaction.
PE1(config)#mpls l2-circuit-fib-entry 500 2000 1000 1.1.1.1 xe13 xe12	Add an FTN entry; where 2000 is the incoming label, 1000 is the outgoing label, 1.1.1.1 is the endpoint, xe12 is the Provider facing interface name, and xe13 access interface name
PE1(config)#commit	Commit the transaction.
PE2(config)#exit	Exit configure mode

Validation

This example shows number of configured VCs and its status.

```
PE1#show mpls vc-table
VC-ID      Vlan-ID    Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label  Nexthop      Status
100        N/A        N/A            xe15           xe1            24320      24321         2.2.2.2      Active
300        N/A        N/A            xe15           xe1            24321      24321         2.2.2.2      Active
500        N/A        N/A            xe15           xe1            2000       24321         2.2.2.2      Active
```

```
PE1#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: t2, id: 100 PW-INDEX: 1 Tunnel-Name: t2
Endpoint: 2.2.2.2
Control Word: 0
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe15
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST1
Match criteria : 2
```

```
MPLS Layer-2 Virtual Circuit: t3, id: 300 PW-INDEX: 2 Tunnel-Name: t2
Operating mode: Raw
Endpoint: 2.2.2.2
Control Word: 0
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe15
Virtual Circuit Type: Ethernet
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST2
Match criteria : 3
```

```
MPLS Layer-2 Virtual Circuit: t5, id: 500 PW-INDEX: 3 Tunnel-Name: t2
Endpoint: 2.2.2.2
Control Word: 0
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe15
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST5
Match criteria : 5
```

```
PE1#show ldp mpls-l2-circuit detail
PW ID: 300, VC state is up
```

```
Access IF: xe15,up,AC state is up
Session IF: xe1, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: ethernet, remote vctype :ethernet
Local groupid: 0, remote groupid: 0
Local label: 26881, remote label: 53760
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:15:48
PW ID: 100, VC state is up
Access IF: xe5,up,AC state is up
Session IF: xe1, state is up
```

```
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26880, remote label: 53761
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:15:48
```

PE2

```
OcNOS#sh mpls vc-table
```

```
VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label Tunnel-Label Nexthop Status
100 N/A N/A xe12 xe3 26880 25600 1.1.1.1 Active
300 N/A N/A xe12 xe3 26881 25600 1.1.1.1 Active
500 N/A N/A xe12 xe3 1000 25600 1.1.1.1 Active
PE2#sh mpls l2-circuit
```

```
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST1
Match criteria : 2
```

```
MPLS Layer-2 Virtual Circuit: t3, id: 300 PW-INDEX: 2 service-tpid: dot1.q
Tunnel-Name: t3
Operating mode: Raw
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST2
Match criteria : 3
```

```
MPLS Layer-2 Virtual Circuit: t5, id: 500 PW-INDEX: 3 service-tpid: dot1.q
Tunnel-Name: t3
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST5
Match criteria : 5
```

```
OcNOS#show ldp mpls-l2-circuit detail
PW ID: 300, VC state is up
Access IF: xe12,up,AC state is up
Session IF: xe3, state is up
Destination: 1.1.1.1, Peer LDP Ident: 1.1.1.1
Local vctype: ethernet, remote vctype :ethernet
```

Local groupid: 0, remote groupid: 0
Local label: 53760, remote label: 26881
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled

MPLS Layer-2 Virtual Circuit: t2, id: 100 PW-INDEX: 1 service-tpid: dot1.q
Tunnel-Name: t3
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No

MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST1
Match criteria : 2

MPLS Layer-2 Virtual Circuit: t3, id: 300 PW-INDEX: 2 service-tpid: dot1.q
Tunnel-Name: t3
Operating mode: Raw
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST2

Match criteria : 3
MPLS Layer-2 Virtual Circuit: t5, id: 500 PW-INDEX: 3 service-tpid: dot1.q
Tunnel-Name: t3
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST5

Match criteria : 5
Ocnos#show ldp mpls-l2-circuit detail
PW ID: 300, VC state is up
Access IF: xe12,up,AC state is up
Session IF: xe3, state is up
Destination: 1.1.1.1, Peer LDP Ident: 1.1.1.1
Local vctype: ethernet, remote vctype :ethernet
Local groupid: 0, remote groupid: 0
Local label: 53760, remote label: 26881
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:17:41


```

PW ID: 100, VC state is up
Access IF: xe12,up,AC state is up
Session IF: xe3, state is up
Destination: 1.1.1.1, Peer LDP Ident: 1.1.1.1
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 53761, remote label: 26880
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:17:41

```

These additional commands can also be used to display information about the Layer 2 virtual circuits.

```

show ldp mpls-l2-circuit detail
show ldp mpls-l2-circuit VC-ID
show ldp mpls-l2-circuit VC-ID detail
show mpls l2-circuit

```

Configure Dynamic VPLS

PE1: LDP VPLS Configuration

(config)#mpls vpls v1 25	Enter VPLS config mode
(config-vpls)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 2.2.2.2 tunnel-name t2	Configure VPLS Peer with trunk-name t2
(config-vpls-sig)#exit	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v2 26	Enter VPLS config mode
(config-vpls)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type ethernet	Type ethernet configuration for VPLS
(config-vpls-sig)#vpls-peer 2.2.2.2 tunnel-name t2	Configure VPLS Peer
(config-vpls-sig)#commit	Commit the transaction.
(config-vpls)#exit	Exit VPLS mode

PE2: LDP VPLS Configuration

(config)#mpls vpls v1 25	Enter VPLS config mode
(config-vpls)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS

(config-vpls-sig)#vpls-peer 1.1.1.1 tunnel-name t3	Configure VPLS Peer
(config-vpls-sig)# exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v2 26	Enter VPLS config mode
(config-vpls)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type ethernet	Type ethernet configuration for VPLS
(config-vpls-sig)#vpls-peer 1.1.1.1 tunnel-name t3	Configure VPLS Peer with tunnel-name t2
(config-vpls-sig)#commit	Commit the transaction.
(config-vpls)#exit	Exit VPLS mode

LDP VPLS Service Mapping Configuration

PE1

#configure terminal	Configure mode
(config)#service-template template1	Template configuration
(config-svc)# match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)# rewrite ingress pop outgoing-tpid dot1.q	Action to be performed for the match.
(config-svc)#exit	Exit template configuration mode
(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config-svc)#commit	Commit the transaction.

PE1: Access port Configuration

(config)#interface xe15	Enter the access interface xe15.
(config-if)#switchport	Configure interface as a layer 2 port.
(config-if)#mpls-vpls v1 service-template template1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v2 service-template template4	Bind the VPLS to the Access Interface.

(config-if-vpls)#commit	Commit the transaction.
(config-if)#exit	Exit Interface mode and return to Configure mode.

PE2

#configure terminal	Configure mode
(config)#service-template template1	Template configuration
(config-svc)# match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)# rewrite ingress pop outgoing-tpid dot1.q	Action to be performed for the match.
(config-svc)#exit	Exit template configuration mode
(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config-svc)#commit	Commit the transaction.

PE2: Access port Configuration

(config)#interface xe12	Enter access Interface xe12
(config-if)#switchport	Configure interface as a layer 2 port.
(config-if)#mpls-vpls v1 service-template template1	Bind the VPLS to the Access Interface.
(config-if-vpls)#exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v2 service-template template4	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#commit	Commit the transaction.
(config-if)#exit	Exit Interface mode and return to Configure mode.

Validation

Below are the example outputs of mpls vpls with tunnel-name

```
PE1#show mpls vpls mesh
VPLS-ID    Peer Addr      Tunnel-Label  In-Label    Network-Intf  Out-Label    Lkps/St    PW-INDEX  SIG-Protocol  Status
25         2.2.2.2        24321        24322       xe1           24322        2/Up       4         LDP           Active
26         2.2.2.2        24321        24323       xe1           24323        2/Up       5         LDP           Active
PE1#

PE1#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
SIG-Protocol: LDP
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
```

Description: none
service-tpid: dot1.ad
Operating mode: Tagged
Svlan Id: 0
Svlan Tpid: 88a8
Configured interfaces:
 Interface: xe15
Service-template : template1
Match criteria : 2024/2023
Action type : Pop
Outgoing tpid : dot1.q

Mesh Peers:
 2.2.2.2 (Up)
 Tunnel-Name: t2

Virtual Private LAN Service Instance: v2, ID: 26
SIG-Protocol: LDP
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.ad
Operating mode: Raw
Configured interfaces:
 Interface: xe15
Service-template : template4
Match criteria : 700,
1200/3200,
Untagged
Action type : Push
Action value : 300

Mesh Peers:
 2.2.2.2 (Up)
 Tunnel-Name: t2

PE2#

PE1#sh mpls vpls mesh

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX	SIG-Protocol	Status
25	2.2.2.2	24321	24322	Xe1	24322	2/Up	4	LDP	Active
26	2.2.2.2	24321	24323	Xe1	24323	2/Up	5	LDP	Active

PE1#

PE2#sh mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25 SIG-Protocol: LDP
Attachment-Circuit :UP Learning: Enabled Control-Word: Disabled
Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500 Description: none
service-tpid: dot1.ad Operating mode: Tagged Svlan Id: 0
Svlan Tpid: 88a8 Configured interfaces:
 Interface: xe15
Service-template : template1 Match criteria : 2024/2023 Action type : Pop
Outgoing tpid : dot1.q
Mesh Peers:
 2.2.2.2 (Up) Tunnel-Name: t2

Virtual Private LAN Service Instance: v2, ID: 26 SIG-Protocol: LDP
Attachment-Circuit :UP Learning: Enabled Control-Word: Disabled
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500 Description: none
service-tpid: dot1.ad Operating mode: Raw Configured interfaces:
 Interface: xe15
Service-template : template4 Match criteria : 700,
1200/3200,
Untagged
Action type : Push Action value : 300
Mesh Peers:
 2.2.2.2 (Up) Tunnel-Name: t2

Configure Static VPLS

PE1: LDP VPLS Configuration

(config)#mpls vpls v3 27	Enter VPLS config mode
(config-vpls)#vpls-peer 2.2.2.2 tunnel-name t2 manual	Configure VPLS Peer with trunk-name t2 with manual option
(config-vpls)#exit	Exit VPLS mode
(config)#service-template vpls1	Template configuration
(config-svc)# match outer-vlan 1000	Allow VLAN 1000 traffic on this VC
(config-svc)#exit	Exit service template mode

PE1: Access port Configuration

(config)#interface xe15	Enter the access Interface xe15
(config-if)#switchport	Configure interface as a layer 2 port.
(config-if)#mpls-vpls v3 service-template vpls1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit from the interface mode
(config)#vpls fib-entry 27 peer 2.2.2.2 3000 xe1 4000	Configure VPLS FIB entry for VPLS peer PE2
(config)#commit	Commit the transaction.

PE2: LDP VPLS Configuration

(config)#mpls vpls v3 27	Enter VPLS config mode
(config-vpls)#vpls-peer 1.1.1.1 tunnel-name t3 manual	Configure static VPLS Peer with tunnel-name t3
(config-vpls)#exit	Exit VPLS mode
(config)#service-template vpls1	Template configuration
(config-svc)# match outer-vlan 1000	Allow VLAN 1000 traffic on this VC
(config-svc)#exit	Exit service template mode

PE2: Access port Configuration

(config)#interface xe12	Enter the access interface xe12
(config-if)#switchport	Configure interface as a layer 2 port.
(config-if)#mpls-vpls v3 service-template vpls1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit-if-vpls	Exit VPLS attachment-circuit mode

(config-if)#exit	Exit interface mode.
(config)#vpls fib-entry 27 peer 1.1.1.1 4000 xe13 3000	Configure VPLS FIB entry for VPLS peer PE1.
(config)#commit	Commit the transaction.

Validation

PE1#show mpls vpls mesh

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX	SIG-Protocol	Status
25	2.2.2.2	24321	24322	xe1	24322	2/Up	4	LDP	Active
26	2.2.2.2	24321	24323	xe1	24323	2/Up	5	LDP	Active
27	2.2.2.2	24321	3000	xe1	4000	2/Up	6	STATIC	Active

PE1#show mpls vpls v3 detail

Virtual Private LAN Service Instance: v3, ID: 27

SIG-Protocol: STATIC

Attachment-Circuit :UP

Learning: Enabled

Control-Word: Disabled

Group ID: 0, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Raw

Configured interfaces:

Interface: xe15

Service-template : vpls1

Match criteria : 1000

Mesh Peers:

2.2.2.2 (Up)

Tunnel-Name: t2

PE2#

PE2#sh mpls vpls mesh

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX	SIG-Protocol	Status
25	2.2.2.2	24321	24322	xe1	24322	2/Up	4	LDP	Active
26	2.2.2.2	24321	24323	xe1	24323	2/Up	5	LDP	Active
27	2.2.2.2	24321	3000	xe1	4000	2/Up	6	STATIC	Active

PE2#

PE2#sh mpls vpls v3 detail

Virtual Private LAN Service Instance: v3, ID: 27 SIG-Protocol: STATIC

Attachment-Circuit :UP Learning: Enabled Control-Word: Disabled

Group ID: 0, Configured MTU: 1500 Description: none

service-tpid: dot1.q Operating mode: Raw Configured interfaces:

Interface: xe15

Service-template : vpls1 Match criteria : 1000

Mesh Peers:

2.2.2.2 (Up) Tunnel-Name: t2

CHAPTER 17 MPLS BFD Configuration

This chapter shows how to configure MPLS-LSP-BFD and PW-VCCV-BFD

BFD can be used to track the liveness of MPLS LSP and also can be used as one of the CV mechanisms in VCCV for PW fault detection and status signaling.

Qumran1 and Qumran2 series platforms support VCCV BFD with the following restrictions:

Qumran 1 Series Platforms	Qumran 2 Series Platforms
Supports both cc-type 1 and 2	Supports only cc-type 1 and cv-type 1 and 3

Topology

Figure 17-8 shows the configuration required to enable MPLS LSP BFD.

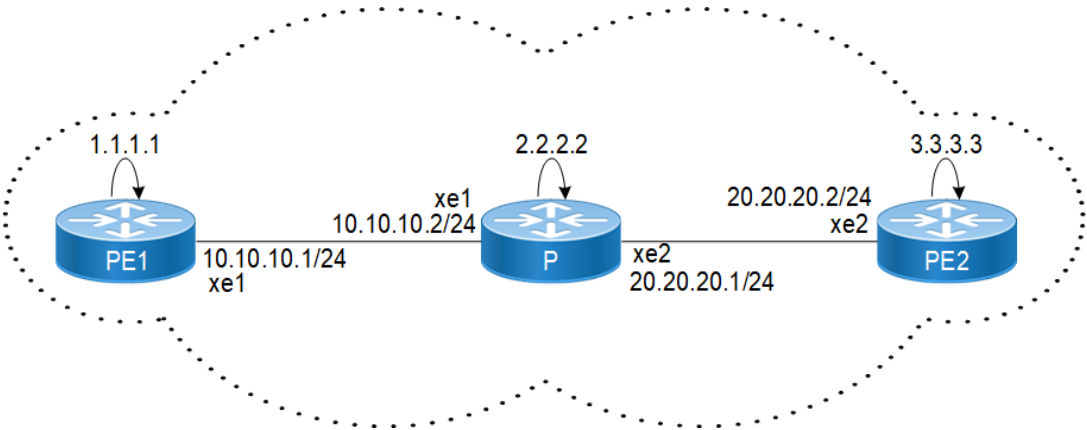


Figure 17-8: MPLS LSP BFD Topology

Configuring MPLS BFD LSP over LDP

PE1

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
(conf)#interface eth1	Enter interface mode
(conf-if)#ip address 10.10.10.1/24	Assign IP address to eth1 interface
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#enable-ldp ipv4	Enable LDP on eth1.
(confi-if)#exit	Exit interface mode

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.10.10.0/24 area 0	Advertise the eth1 interface in OSPF area 0.
(config-router)#network 1.1.1.1/32 area 0	Advertise the lo interface in OSPF area 0.
(config-router)#exit	Exit router mode
(config)#mpls bfd ldp all	Configure mpls bfd for ldp
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

P

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if)#exit	Exit interface mode.
(config)#interface eth1	Specify the interface (eth1) to be configured.
(conf-if)#ip address 10.10.10.2/24	Assign IP address to eth1 interface
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (eth1).
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Specify the interface (eth2) to be configured.
(conf-if)#ip address 20.20.20.1/24	Assign IP address to eth2 interface
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (eth2).
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter Router mode.
(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#exit	Exit Router mode and return to Configure mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.

(config-router)#network 10.10.10.0/24 area 0	Define the interfaces on which OSPF runs and associate the area ID (0) with them.
(config-router)#network 20.20.20.0/24 area 0	Define the interfaces on which OSPF runs and associate the area ID (0) with them.
(config-router)#network 2.2.2.2/32 area 0	Define the interfaces on which OSPF runs and associate the area ID (0) with them.
(config)#mpls bfd ldp all	Configure mpls bfd for ldp
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

PE2

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Specify the interface (eth2) to be configured.
(config-if)#ip address 20.20.20.2/24	Assign IP address to eth2 interface
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (eth2).
(config-if)#commit	Commit the transaction.
(config-if)#exit	Exit Interface mode
(config)#router ldp	Enter Router mode.
(config-router)#router-id 3.3.3.3	Set the router ID for IP address 3.3.3.3.
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 20.20.20.0/24 area 0	Define the interfaces on which OSPF runs and associate the area ID (0) with them.
(config-router)#network 3.3.3.3/32 area 0	Define the interfaces on which OSPF runs and associate the area ID (0) with them.
(config-router)#commit	Commit the transaction.
(config)#mpls bfd ldp all	Configure mpls bfd for ldp
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

Validation

Validation 1

Verify OSPF neighbor adjacency between all 5 routers.

PE1#show ip ospf neighbor

Total number of full neighbors: 1

OSPF process 1 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
2.2.2.2 0	1	Full/DR	00:00:32	10.10.10.2	eth1

P#show ip ospf neighbor

Total number of full neighbors: 2

OSPF process 1 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
1.1.1.1 0	1	Full/Backup	00:00:35	10.10.10.1	eth1
3.3.3.3 0	1	Full/Backup	00:00:32	20.20.20.2	eth2

PE2#show ip ospf neighbor

Total number of full neighbors: 1

OSPF process 1 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
2.2.2.2 0	1	Full/DR	00:00:31	20.20.20.1	eth1

Validation 2

Verify that ldp session on all 3 nodes have come up.

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	eth1	Passive	OPERATIONAL	30	01:30:57

P#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	eth1	Active	OPERATIONAL	30	01:48:34
3.3.3.3	eth2	Passive	OPERATIONAL	30	03:01:14

PE2#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	eth2	Active	OPERATIONAL	30	03:01:14

Validation 3

The command output below displays the LSP sessions with LDP as signaling protocol.

```
PE1# #show bfd mpls lsp sessions
```

Peer	Addr	Min	Path	Tunnel-name	State	Local
Local	Min	Min	Encap	Last		
Multi	Tx	Rx		Dn-Time		Disc
2.2.2.2			LDP LSP		Up	1281
3	10000	10000	IP/UDP	00:00:00		
3.3.3.3			LDP LSP		Up	1282
3	10000	10000	IP/UDP	00:00:00		
0.0.0.0			LDP LSP		Up	1283
3	3000	3000	IP/UDP	00:00:00		
0.0.0.0			LDP LSP		Up	1284
3	3000	3000	IP/UDP	00:00:00		

```
P #show bfd mpls lsp sessions
```

Peer	Addr	Min	Path	Tunnel-name	State	Local
Local	Min	Min	Encap	Last		
Multi	Tx	Rx		Dn-Time		Disc
3.3.3.3			LDP LSP		Up	1283
3	10000	10000	IP/UDP	00:00:00		
0.0.0.0			LDP LSP		Up	1281
3	3000	3000	IP/UDP	00:00:00		
1.1.1.1			LDP LSP		Up	1282
3	10000	10000	IP/UDP	00:00:00		
0.0.0.0			LDP LSP		Up	1284
3	3000	3000	IP/UDP	00:00:00		

```
PE1 #show bfd mpls lsp sessions
```

Peer	Addr	Min	Path	Tunnel-name	State	Local
Local	Min	Min	Encap	Last		
Multi	Tx	Rx		Dn-Time		Disc
2.2.2.2			LDP LSP		Up	1282
3	10000	10000	IP/UDP	00:00:00		
0.0.0.0			LDP LSP		Up	1283
3	3000	3000	IP/UDP	00:00:00		
1.1.1.1			LDP LSP		Up	1281
3	10000	10000	IP/UDP	00:00:00		
0.0.0.0			LDP LSP		Up	1284
3	3000	3000	IP/UDP	00:00:00		

Configuring MPLS BFD LSP over RSVP

This section shows how to configure RSVP session between PE1 and PE2 and MPLS BFD.

Note: For OSPF configurations, please refer 'Configuring MPLS BFD LSP over LDP' section.

PE1

(config)#router rsvp	Enter Router mode for RSVP.
(config-router)#exit	Exit RSVP router mode
(conf)#interface eth1	Enter interface mode
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#enable-rsvp	Enable RSVP on eth1.
(confi-if)#exit	Exit interface mode
(config)#rsvp-trunk T1 ipv4	Configure Trunk for RSVP
(config-trunk)# from 1.1.1.1	Specify tunnel ingress for RSVP
(config-trunk)# to 3.3.3.3	Specify tunnel egress for RSVP
(config-trunk)#exit	Exit RSVP trunk configuration mode
(config)#mpls bfd rsvp all	Configure mpls bfd for RSVP
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

P

(config)#router rsvp	Enter Router mode for RSVP.
(config-router)#exit	Exit RSVP router mode
(conf)#interface eth1	Enter interface mode
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#enable-rsvp	Enable RSVP on eth1.
(confi-if)#exit	Exit interface mode
(conf)#interface eth2	Enter interface mode
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-rsvp	Enable RSVP on eth2.
(confi-if)#exit	Exit interface mode
(config)#mpls bfd rsvp all	Configure mpls bfd for RSVP
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

PE2

(config)#router rsvp	Enter Router mode for RSVP.
(config-router)#exit	Exit RSVP router mode
(conf)#interface eth2	Enter interface mode
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-rsvp	Enable RSVP on eth2.
(confi-if)#exit	Exit interface mode
(config)#rsvp-trunk T1 ipv4	Configure Trunk for RSVP
(config-trunk)# from 3.3.3.3	Specify tunnel ingress for RSVP
(config-trunk)# to 1.1.1.1	Specify tunnel egress for RSVP
(config-trunk)#exit	Exit RSVP trunk configuration mode
(config)#mpls bfd rsvp all	Configure mpls bfd for RSVP
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

Validation

Validation 1

Verify RSVP session is up and running between PE nodes.

```
PE1#show rsvp session
```

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass

State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary

* indicates the session is active with local repair at one or more nodes

(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:

To Style	From Labelin Labelout	Type DSType	LSPName	State	Uptime	Rt
3.3.3.3	1.1.1.1	PRI	T1-Primary	UP	00:35:38	
1 1 SE	- 24321	DEFAULT				

Total 1 displayed, Up 1, Down 0.

Egress RSVP:

To Style	From Labelin Labelout	Type DSType	LSPName	State	Uptime	Rt
1.1.1.1	3.3.3.3	PRI	T1-Primary	UP	00:35:51	
1 1 SE	24320 -	ELSP_CON				

Total 1 displayed, Up 1, Down 0.

```
PE2#show rsvp session
```

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass

State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary

* indicates the session is active with local repair at one or more nodes

(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:

To Style	Labelin	From Labelout	Type DSType	LSPName	State	Uptime	Rt
1.1.1.1		3.3.3.3	PRI	T1-Primary	UP	00:37:51	
1 1 SE	-	24320	DEFAULT				

Total 1 displayed, Up 1, Down 0.

Egress RSVP:

To Style	Labelin	From Labelout	Type DSType	LSPName	State	Uptime	Rt
3.3.3.3		1.1.1.1	PRI	T1-Primary	UP	00:37:38	
1 1 SE	24320	-	ELSP_CON				

Validation 2

The command output below displays the LSP sessions with RSVP.

PE1#show bfd mpls lsp sessions

Peer	Addr	Min	Path	Tunnel-name	State	Local
Local	Min	Min	Encap	Last		
Multi	Tx	Rx		Dn-Time		
3.3.3.3			RSVP LSP	T1	Up	1282
3	10000	10000	IP/UDP	00:00:00		

PE2#show bfd mpls lsp sessions

Peer	Addr	Min	Path	Tunnel-name	State	Local
Local	Min	Min	Encap	Last		
Multi	Tx	Rx		Dn-Time		
1.1.1.1			RSVP LSP	T1	Up	1281
3	10000	10000	IP/UDP	00:00:00		

Configuring Static MPLS BFD

This section shows how to configure MPLS BFD statically.

Note: For OSPF configurations, please refer 'Configuring MPLS BFD LSP over LDP' section.

PE1

(config)#interface eth1	Enter interface mode
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#exit	Exit interface mode
(conf)#mpls ftn-entry 3.3.3.3/32 102 10.10.10.2 eth1	Configure MPLS FTN entry for the creation of a static LSP to

PE-2.	
(config)#mpls ilm-entry 401 pop	Configure ILM entry
(config)#mpls bfd static all	Configure mpls bfd for static MPLS
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

P

(config)#interface eth1	Enter interface mode
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#exit	Exit interface mode
(config)#interface eth2	Enter interface mode
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#exit	Exit interface mode
mpls ilm-entry 201 swap 401 eth1 10.10.10.1 1.1.1.1/32	Swap the incoming label
mpls ilm-entry 102 swap 301 eth2 mpls ftn-entry 1.1.1.1/32 201 20.20.20.1 eth2 20.20.20.2 3.3.3.3/32	Swap the incoming label
(config)#mpls bfd static all	Configure mpls bfd for static MPLS
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

PE2

(config)#interface eth2	Enter interface mode
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#exit	Exit interface mode
(config)#mpls ftn-entry 1.1.1.1/32 201 20.20.20.1 eth2	Configure MPLS FTN entry for the creation of a static LSP to
PE-1	
(config)#mpls bfd static all	Configure mpls bfd for static MPLS
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

Validations

Validation 1

Verify static MPLS BFD session is up and running between PE nodes.

```
PE1#show bfd mpls lsp sessions
```

Peer	Addr	Min	Path	Tunnel-name	State	Local
Local	Min	Min	Encap	Last		
Multi	Tx	Rx		Dn-Time		
3.3.3.3			Static LSP		Up	1281
3	10000	10000	IP/UDP	00:00:00		

```
PE2#show bfd mpls lsp sessions
```

Peer	Addr	Min	Path	Tunnel-name	State	Local
Local	Min	Min	Encap	Last		
Multi	Tx	Rx		Dn-Time		
1.1.1.1			Static LSP		Up	1281
3	10000	10000	IP/UDP	00:00:00		

Configuring PW VCCV BFD

This section shows how to configure PW VCCV BFD.

Note: For OSPF configurations, please refer 'Configuring MPLS BFD LSP over LDP' section.

PE1

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
(conf)#interface eth1	Enter interface mode
(conf-if)#ip address 10.10.10.1/24	Assign IP address to eth1 interface
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#enable-ldp ipv4	Enable LDP on eth1.
(confi-if)#exit	Exit interface mode
(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#service-template st1	Service template configuration
(config-svc)#exit	Exit service-template configuration mode
(config)#mpls l2-circuit pw1 3.3.3.3	Configure the VC for PE2

(config-pseudowire)#control-word	Configure control-word
(config-pseudowire)#vccv cc-type type-1	Configure cc-type type-1
(config-pseudowire)#vccv cv-type type-3	Configure cv-type type-3
(config-pseudowire)#exit	Exit pw configuration mode
(config)#commit	Commit the candidate configuration to the running configuration

P

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if)#exit	Exit interface mode.
(config)#interface eth1	Specify the interface (eth1) to be configured.
(config-if)#ip address 10.10.10.2/24	Assign IP address to eth1 interface
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (eth1).
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Specify the interface (eth2) to be configured.
(config-if)#ip address 20.20.20.1/24	Assign IP address to eth2 interface
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (eth2).
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter Router mode.
(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#pw-status-tlv	Configure PW Status TLV to signal the pseudowire status
(config-router)#exit	Exit Router mode and return to Configure mode.
(config)#commit	Commit the candidate configuration to the running configuration

PE2

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32.
(config-if)#exit	Exit interface mode.
(config)#interface eth1	Specify the interface (eth1) to be configured.
(config-if)#ip address 20.20.20.2/24	Assign IP address to eth1 interface
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (eth2).
(config-if)#commit	Commit the transaction.

(config-if)#exit	Exit Interface mode
(config)#router ldp	Enter Router mode.
(config-router)#router-id 3.3.3.3	Set the router ID for IP address 3.3.3.3.
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#service-template st1	Service template configuration
(config-svc)#exit	Exit service-template configuration mode
(config)#mpls l2-circuit pw1 1.1.1.1	Configure the VC for PE1
(config-pseudowire)#control-word	Configure control-word
(config-pseudowire)#vccv cc-type type-1	Configure cc-type type-1
(config-pseudowire)#vccv cv-type type-3	Configure cv-type type-3
(config-pseudowire)#exit	Exit pw configuration mode

Validation

Validation 1

Verify PW VCCV BFD sessions are up between PE nodes.

PE1#show bfd mpls pw-vccv sessions

VC-ID	Peer Addr	State	Local	Local	Min	Min	
Encap	Last		Disc	Multi	Tx	Rx	
Dn-Time							
1	3.3.3.3	Up	1281	3	3000	3000	PW-
ACH	00:00:00						

PE2#show bfd mpls pw-vccv sessions

VC-ID	Peer Addr	State	Local	Local	Min	Min	
Encap	Last		Disc	Multi	Tx	Rx	
Dn-Time							
1	1.1.1.1	Up	1281	3	3000	3000	PW-
ACH	00:00:00						

CHAPTER 18 BGP Peer Groups for Address-Family L2VPN EVPN

BGP peer groups are used to simplify configuration and to improve performance. This is achieved by assigning the same outbound policy to each of the neighbors. Because UPDATES are generated only once per peer group rather than multiple times for each neighboring router, peer groups save processing time when building neighbor updates. It reduces the amount of system resources (CPU and memory) necessary in an update generation.

A BGP peer group reduces the load on system resources by allowing the routing table to be checked only once, and updates to be replicated to all peer group members instead of being done individually for each peer in the peer group.

Topology

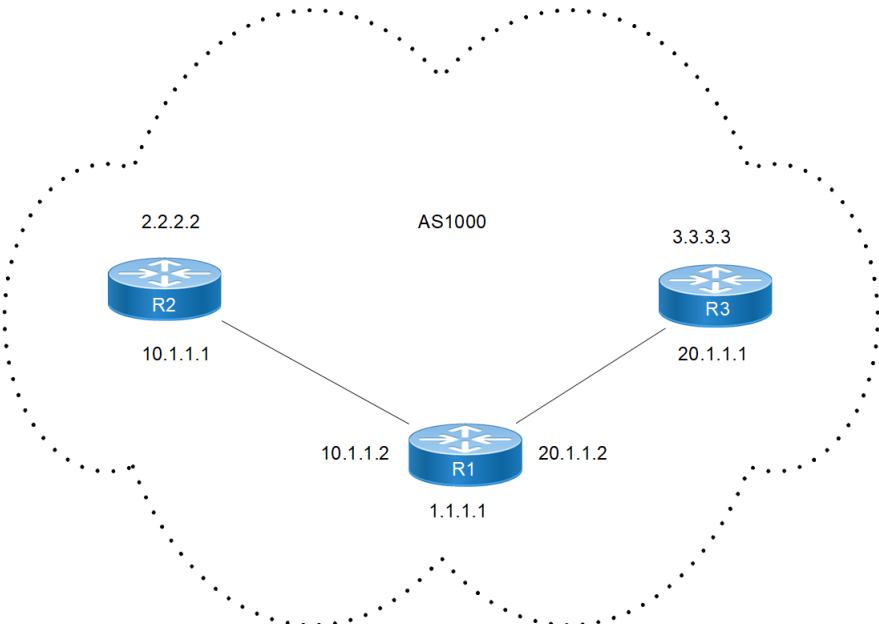


Figure 18-9: BGP Peer-Groups with L2VPN EVPN address-family

Configuration

R1

#configure terminal	Enter configure mode.
(config)# interface lo	Enter interface mode for Loopback
(config-if)#ip address 1.1.1.1/32 secondary	Configure ip address for Loopback interface
(config-if)#exit	Exit interface mode
(config)# interface xe15	Enter interface mode for xe15
(config-if)#ip address 10.1.1.2/24	Configure ip address
(config-if)#exit	Exit interface mode

(config)# interface ce0	Enter interface mode for ce0
(config-if)#ip address 20.1.1.2	Configure ip address
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the OSPF process (100)
(config-router)# ospf router-id 1.1.1.1	Configure OSPF router-id
(config-router)#network 1.1.1.1/32 area 0	Advertise the network in Area 0
(config-router)#network 10.1.1.0/24 area 0	Advertise the network in Area 0
(config-router)#network 20.1.1.0/24 area 0	Advertise the network in Area 0
(config-router)#exit	Exit Router mode and return to Configure mode
(config)#router bgp 100	Define the routing process. The number 100 specifies the AS number of R1.
(config-router)# bgp router-id 1.1.1.1	Configure BGP router-id
(config-router)#neighbor PG peer-group	Create a peer group named PG
(config-router)#neighbor PG remote-as 100	Assign options to the peer group named PG
(config-router)#neighbor PG update-source lo	Assign options to the peer group named PG
(config-router)#neighbor 2.2.2.2 peer-group PG	Define neighbor 2.2.2.2 (R2) as a peer group
(config-router)#neighbor 3.3.3.3 peer-group PG	Define neighbor 3.3.3.3 (R3) as a peer group member.
(config-router)#address-family l2vpn evpn	Enter address-family l2vpn evpn mode
(config-router-af)#neighbor PG activate	Activate the peer-group ABC for address-family l2vpn evpn
(config-router-af)# exit-address-family	Exit address-family ipv4 unicast mode
(config-router)#exit	Exit router bgp mode
(config)#commit	Commit the candidate configuration to the running configuration.

R2

#configure terminal	Enter configure mode.
(config)# interface lo	Enter interface mode for Loopback
(config-if)#ip address 2.2.2.2/32 secondary	Configure ip address for Loopback interface
(config-if)#exit	Exit interface mode
(config)# interface xe15	Enter interface mode for xe15
(config-if)#ip address 10.1.1.2/24	Configure ip address
(config-if)#exit	Exit interface mode
(config)# interface xe10	Enter interface mode for xe10
(config-if)#ip address 10.1.1.1/24	Configure ip address
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the OSPF process (100)
(config-router)# ospf router-id 2.2.2.2	Configure OSPF router-id
(config-router)#network 2.2.2.2/32 area 0	Advertise the network in Area 0
(config-router)#network 10.1.1.0/24 area 0	Advertise the network in Area 0
(config-router)#exit	Exit Router mode and return to Configure mode

(config)#router bgp 100	Define the routing process. The number 100 specifies the AS number of R1.
(config-router)# bgp router-id 2.2.2.2	Configure BGP router-id
(config-router)#neighbor PG peer-group	Create a peer group named PG
(config-router)#neighbor PG remote-as 100	Assign options to the peer group named PG
(config-router)#neighbor PG update-source lo	Assign options to the peer group named PG
(config-router)#neighbor 1.1.1.1 peer-group PG	Define neighbor 1.1.1.1 (R1) as a peer group member.
(config-router)#address-family l2vpn evpn	Enter address-family l2vpn evpn mode
(config-router-af)#neighbor PG activate	Activate the peer-group ABC for address-family l2vpn evpn
(config-router-af)# exit-address-family	Exit address-family ipv4 unicast mode
(config-router)#exit	Exit router bgp mode
(config)#commit	Commit the candidate configuration to the running configuration.

R3

#configure terminal	Enter configure mode.
(config)# interface lo	Enter interface mode for Loopback
(config-if)#ip address 3.3.3.3/32 secondary	Configure ip address for Loopback interface
(config-if)#exit	Exit interface mode
(config)# interface ce15	Enter interface mode for ce15
(config-if)#ip address 20.1.1.1/24	Configure ip address
(config-if)#exit	Exit interface mode
(config)# interface xe10	Enter interface mode for xe10
(config-if)#ip address 10.1.1.1/24	Configure ip address
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the OSPF process (100)
(config-router)# ospf router-id 3.3.3.3	Configure OSPF router-id
(config-router)#network 20.1.1.0/24 area 0	Advertise the network in Area 0
(config-router)#exit	Exit Router mode and return to Configure mode
(config)#router bgp 100	Define the routing process. The number 100 specifies the AS number of R1.
(config-router)# bgp router-id 3.3.3.3	Configure BGP router-id
(config-router)#neighbor PG peer-group	Create a peer group named PG
(config-router)#neighbor PG remote-as 100	Assign options to the peer group named PG
(config-router)#neighbor PG update-source lo	Assign options to the peer group named PG
(config-router)#neighbor 1.1.1.1 peer-group PG	Define neighbor 1.1.1.1 (R1) as a peer group member.
(config-router)#address-family l2vpn evpn	Enter address-family l2vpn evpn mode
(config-router-af)#neighbor PG activate	Activate the peer-group ABC for address-family l2vpn evpn
(config-router-af)# exit-address-family	Exit address-family ipv4 unicast mode

(config-router)#exit	Exit router bgp mode
(config)#commit	Commit the candidate configuration to the running configuration.

Validation

R1

```
R1#sh run bgp
!
router bgp 100
  bgp router-id 1.1.1.1
  neighbor PG peer-group
  neighbor PG remote-as 100
  neighbor PG update-source lo
  neighbor 2.2.2.2 peer-group PG
  neighbor 3.3.3.3 peer-group PG
!
address-family l2vpn evpn
  neighbor PG activate
exit-address-family
R1#sh bgp neighbors
BGP neighbor is 2.2.2.2, remote AS 100, local AS 100, internal link
Member of peer-group PG for session parameters
  BGP version 4, local router ID 1.1.1.1, remote router ID 2.2.2.2
  BGP state = Established, up for 01:20:53
  Last read 00:00:24, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family L2VPN EVPN: advertised and received
  Received 192 messages, 0 notifications, 0 in queue
  Sent 191 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 5 seconds
  Update source is lo
For address family: L2VPN EVPN
  BGP table version 1, neighbor version 1
  Index 2, Offset 0, Mask 0x4
  PG peer-group member
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  0 accepted prefixes
  Accepted AD:0 MACIP:0 MCAST:0 ESI:0 PREFIX:0
  0 announced prefixes

Connections established 1; dropped 0
Local host: 1.1.1.1, Local port: 42981
Foreign host: 2.2.2.2, Foreign port: 179
```

Nexthop: 1.1.1.1
 Nexthop global: ::
 Nexthop local: ::
 BGP connection: non shared network

BGP neighbor is 3.3.3.3, remote AS 100, local AS 100, internal link
 Member of peer-group PG for session parameters
 BGP version 4, local router ID 1.1.1.1, remote router ID 3.3.3.3
 BGP state = Established, up for 01:36:13
 Last read 00:00:08, hold time is 90, keepalive interval is 30 seconds
 Neighbor capabilities:
 Route refresh: advertised and received (old and new)
 Address family L2VPN EVPN: advertised and received
 Received 227 messages, 0 notifications, 0 in queue
 Sent 229 messages, 0 notifications, 0 in queue
 Route refresh request: received 0, sent 0
 Minimum time between advertisement runs is 5 seconds
 Update source is lo
 For address family: L2VPN EVPN
 BGP table version 1, neighbor version 1
 Index 3, Offset 0, Mask 0x8
 PG peer-group member
 Community attribute sent to this neighbor (both)
 Large Community attribute sent to this neighbor
 0 accepted prefixes
 Accepted AD:0 MACIP:0 MCAST:0 ESI:0 PREFIX:0
 0 announced prefixes

Connections established 1; dropped 0
 Local host: 1.1.1.1, Local port: 179
 Foreign host: 3.3.3.3, Foreign port: 32857
 Nexthop: 1.1.1.1
 Nexthop global: ::
 Nexthop local: ::
 BGP connection: non shared network
 R1#sh ip ospf neighbor

Total number of full neighbors: 2
 OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
2.2.2.2	1	Full/Backup	00:00:38	10.1.1.1	xe15	0
3.3.3.3	1	Full/Backup	00:00:34	20.1.1.1	ce0	0

R1#sh bgp l2vpn evpn summary
 BGP router identifier 1.1.1.1, local AS number 100
 BGP table version is 1
 1 BGP AS-PATH entries
 0 BGP community entries

Neighbor PfxRcd	AD	MACIP	V MCAST	AS	MsgRcv ESI	MsgSen PREFIX-ROUTE	TblVer	InQ	OutQ	Up/Down	State/
--------------------	----	-------	------------	----	---------------	------------------------	--------	-----	------	---------	--------

2.2.2.2			4	100	193	191	1	0	0	01:21:07
0	0	0	0	0	0					
3.3.3.3			4	100	227	229	1	0	0	01:36:27
0	0	0	0	0	0					

Total number of neighbors 2

Total number of Established sessions 2

R2

R2#sh run bgp

!

router bgp 100

bgp router-id 2.2.2.2

neighbor PG peer-group

neighbor PG remote-as 100

neighbor PG update-source lo

neighbor 1.1.1.1 peer-group PG

!

address-family l2vpn evpn

neighbor PG activate

exit-address-family

!

R2#sh bgp neighbors

BGP neighbor is 1.1.1.1, remote AS 100, local AS 100, internal link

Member of peer-group PG for session parameters

BGP version 4, local router ID 2.2.2.2, remote router ID 1.1.1.1

BGP state = Established, up for 01:20:42

Last read 00:00:20, hold time is 90, keepalive interval is 30 seconds

Neighbor capabilities:

Route refresh: advertised and received (old and new)

Address family L2VPN EVPN: advertised and received

Received 190 messages, 0 notifications, 0 in queue

Sent 193 messages, 0 notifications, 0 in queue

Route refresh request: received 0, sent 0

Minimum time between advertisement runs is 5 seconds

Update source is lo

For address family: L2VPN EVPN

BGP table version 1, neighbor version 1

Index 2, Offset 0, Mask 0x4

PG peer-group member

Community attribute sent to this neighbor (both)

Large Community attribute sent to this neighbor

0 accepted prefixes

Accepted AD:0 MACIP:0 MCAST:0 ESI:0 PREFIX:0

0 announced prefixes

Connections established 1; dropped 0

Local host: 2.2.2.2, Local port: 179

Foreign host: 1.1.1.1, Foreign port: 42981


```

Nexthop: 2.2.2.2
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

```

```
R2#sh ip ospf neighbor
```

```
Total number of full neighbors: 1
```

```
OSPF process 100 VRF(default):
```

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
1.1.1.1	1	Full/DR	00:00:30	10.1.1.2	xe10	0

```
R2#sh bgp l2vpn evpn summary
```

```
BGP router identifier 2.2.2.2, local AS number 100
```

```
BGP table version is 1
```

```
0 BGP AS-PATH entries
```

```
0 BGP community entries
```

Neighbor PfxRcd	AD	MACIP	V MCAST	AS	MsgRcv ESI	MsgSen PREFIX-ROUTE	TblVer	InQ	OutQ	Up/Down	State/
1.1.1.1			4	100	192	195	1	0	0	01:21:28	
0	0	0	0	0	0						

```
Total number of neighbors 1
```

```
Total number of Established sessions 1
```

R3

```
R3#sh run bgp
```

```
!
```

```
router bgp 100
```

```
  bgp router-id 3.3.3.3
```

```
  neighbor PG peer-group
```

```
  neighbor PG remote-as 100
```

```
  neighbor PG update-source lo
```

```
  neighbor 1.1.1.1 peer-group PG
```

```
!
```

```
  address-family l2vpn evpn
```

```
  neighbor PG activate
```

```
  exit-address-family
```

```
!
```

```
R3#sh bgp neighbors
```

```
BGP neighbor is 1.1.1.1, remote AS 100, local AS 100, internal link
```

```
Member of peer-group PG for session parameters
```

```
BGP version 4, local router ID 3.3.3.3, remote router ID 1.1.1.1
```

```
BGP state = Established, up for 01:36:07
```

```
Last read 00:00:06, hold time is 90, keepalive interval is 30 seconds
```

```
Neighbor capabilities:
```

```
  Route refresh: advertised and received (old and new)
```

```
  Address family L2VPN EVPN: advertised and received
```

Received 228 messages, 0 notifications, 0 in queue
Sent 227 messages, 0 notifications, 0 in queue
Route refresh request: received 0, sent 0
Minimum time between advertisement runs is 5 seconds
Update source is lo
For address family: L2VPN EVPN
BGP table version 1, neighbor version 1
Index 2, Offset 0, Mask 0x4
PG peer-group member
Community attribute sent to this neighbor (both)
Large Community attribute sent to this neighbor
0 accepted prefixes
Accepted AD:0 MACIP:0 MCAST:0 ESI:0 PREFIX:0
0 announced prefixes

Connections established 1; dropped 0
Local host: 3.3.3.3, Local port: 32857
Foreign host: 1.1.1.1, Foreign port: 179
Nexthop: 3.3.3.3
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
R3#sh ip os neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	
1.1.1.1	1	Full/DR	00:00:37	20.1.1.2	ce15	0

R3#sh bgp l2vpn evpn summary

BGP router identifier 3.3.3.3, local AS number 100

BGP table version is 1

0 BGP AS-PATH entries

0 BGP community entries

Neighbor	AD	MACIP	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
PfxRcd			MCAST		ESI	PREFIX-ROUTE					
1.1.1.1			4	100	232	231	1	0	0	01:37:55	
0	0	0	0	0	0						

Total number of neighbors 1

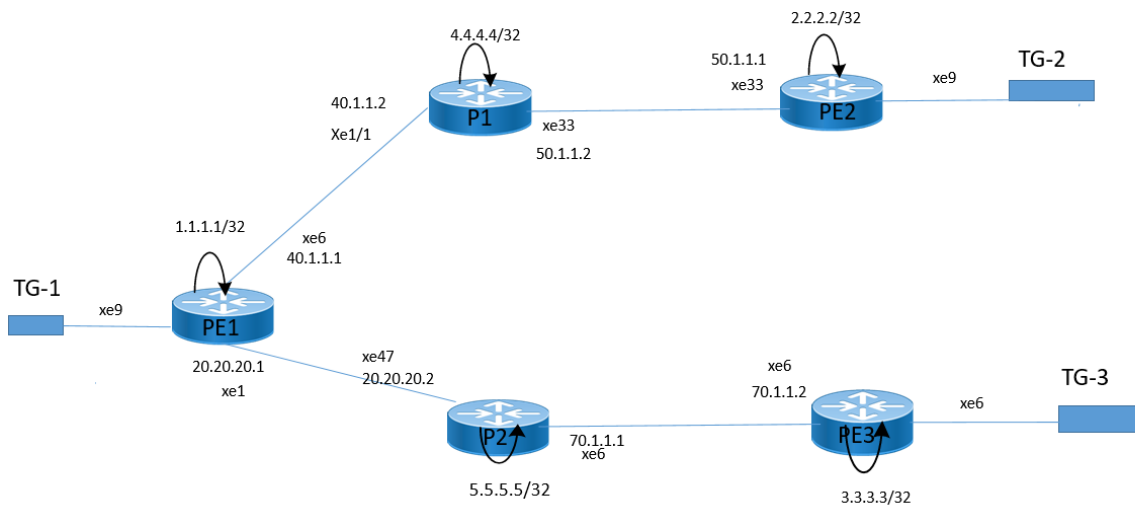
Total number of Established sessions 1

CHAPTER 19 Point-to-Point Connections Over MPLS

Overview

An MPLS Layer 2 Virtual Circuit (VC) facilitates efficient point-to-point Layer 2 connectivity in a service providers MPLS network. It enables Layer 2 circuit transport across the providers infrastructure, ensuring secure communication between remote sites through a single Label Switched Path (LSP) tunnel connecting Provider Edge (PE) routers. This feature optimizes network performance and supports diverse applications and services.

Topology



The VC configuration process can be divided into the following steps:

Note: Loopback addresses being used should be advertised through OSPF, or must be statically routed.

1. Configure the IP address and OSPF for the PE-1, P (Provider), and PE-2 routers.
2. Configure MPLS and LDP on PE-1, P, and PE-2, and LDP targeted peer for the PE-1 and PE-2 routers. (If RSVP is used for configuring trunks, LDP must be configured on PE-1 and PE-2, and RSVP must be configured on PE-1, P, and PE-2.)
3. Configure the VC.
4. Bind the customer interface to the VC.

Configure IP Address and OSPF on Routers

Configure the IP addresses and OSPF on the PE-1, P1, P2, PE2 and PE-3 routers.

PE-1

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback interface (lo0) to be configured.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe6	Specify the interface (xe6) to be configured.
(config-if)#ip address 40.1.1.1/24	Set the IP address of the interface to 40.1.1.1/24
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 20.20.20.1/24	Set the IP address of the interface to 20.20.20.1/24
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 40.1.1.0/24 area 0 (config-router)#network 1.1.1.1/32 area 0 (config-router)#network 20.20.20.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.

P1

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback interface (lo0) to be configured.
(config-if)#ip address 4.4.4.4/32 secondary	Set the IP address of the loopback interface to 4.4.4.4/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe1/1	Specify the interface (xe1/1) to be configured.
(config-if)#ip address 40.1.1.2/24	Set the IP address of the interface to 40.1.1.2/24.
(config-if)#exit	Exit interface mode.
(config)#interface xe33	Specify the interface (xe33) to be configured.
(config-if)#ip address 50.1.1.2/24	Set the IP address of the interface to 50.1.1.2/24.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 40.1.1.0/24 area 0 (config-router)#network 50.1.1.0/24 area 0 (config-router)#network 4.4.4.4/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.

P2

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback interface (lo0) to be configured.
(config-if)#ip address 5.5.5.5/32 secondary	Set the IP address of the loopback interface to 5.5.5.5/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe6	Specify the interface (xe1/1) to be configured.
(config-if)#ip address 70.1.1.1/24	Set the IP address of the interface to 70.1.1.1/24.
(config-if)#exit	Exit interface mode.
(config)#interface xe47	Specify the interface (xe47) to be configured.
(config-if)#ip address 20.20.20.2/24	Set the IP address of the interface to 20.20.20.2/24.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 20.20.20.2/24 area 0 (config-router)#network 70.1.1.0/24 area 0 (config-router)#network 5.5.5.5/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.

PE-2

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback interface (lo0) to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe33	Specify the interface (xe33) to be configured.
(config-if)#ip address 50.1.1.1/24	Set the IP address of the interface to 50.1.1.1/24
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 50.1.1.0/24 area 0 (config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs, and associate the area ID (0) with the interface.

PE-3

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback interface (lo0) to be configured.

(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe6	Specify the interface (xe33) to be configured.
(config-if)#ip address 70.1.1.2/24	Set the IP address of the interface 70.1.1.2/24
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 70.1.1.0/24 area 0 (config-router)#network 3.3.3.3/32 area 0	Define the interface on which OSPF runs, and associate the area ID (0) with the interface.

Configure MPLS, LDP, and LDP Targeted Peer on Routers

PE-1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)# router-id 1.1.1.1	Configure LDP router ID.
(config-router)#pw-status-tlv	Set PW status TLV
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 2.2.2.2	Specify the targeted LDP peer on PE-1.
(config-router)#targeted-peer ipv4 3.3.3.3	Specify the targeted LDP peer on PE-1.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the Router mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config)#interface xe6	Specify the interface (xe6) to be configured.
(config-if)#label-switching	Enable label switching on interface xe6
(config-if)#enable-ldp ipv4	Enable LDP on interface xe6.

PE2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)# router-id 2.2.2.2	Configure LDP router ID.
(config-router)#pw-status-tlv	Set PW status TLV

(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 1.1.1.1	Specify the targeted LDP peer on PE-1.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the Router mode.
(config)#interface xe33	Specify the interface (xe33) to be configured.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe33.

PE3

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)# router-id 3.3.3.3	Configure LDP router ID.
(config-router)#pw-status-tlv	Set PW status TLV
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 1.1.1.1	Specify the targeted LDP peer on PE-1.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the Router mode.
(config)#interface xe6	Specify the interface (xe6) to be configured.
(config-if)#label-switching	Enable label switching on interface xe6.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe6.

P1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)# router-id 4.4.4.4	Configure LDP router ID.
(config-router)#exit	Exit the Router mode.
(config)#interface xe1/1	Specify the interface (xe1/1) to be configured.
(config-if)#label-switching	Enable label switching on interface xe1/1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config)#interface xe33	Specify the interface (xe6) to be configured.
(config-if)#label-switching	Enable label switching on interface xe33.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe33.

P2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)# router-id 5.5.5.5	Configure LDP router ID.
(config-router)#exit	Exit the Router mode.
(config)#interface xe6	Specify the interface (xe6) to be configured.
(config-if)#label-switching	Enable label switching on interface xe6.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe6.
(config)#interface xe47	Specify the interface (xe47) to be configured.
(config-if)#label-switching	Enable label switching on interface xe47.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe47.

Configure VC

Configure the VC. Each VC ID uniquely identifies the Layer-2 circuit among all the Layer-2 circuits.

PE-1

#configure terminal	Enter configure mode.
(config)# mpls l2-circuit VPLS-100-1 10000100 3.3.3.3	Configure the VC for PE-3. In this example, VPLS-100-1 is the VC name, 10000100 is the VC ID, and 3.3.3.3 is the VC endpoint IP address.
(config-pseudowire)# mpls l2-circuit VPLS-200-3 30000200 2.2.2.2	Configure the VC for PE-2. In this example, VPLS-200-3 is the VC name, 30000200 is the VC ID, and 2.2.2.2 is the VC endpoint IP address.

PE-2

#configure terminal	Enter configure mode.
(config)# mpls l2-circuit VPLS-200-3 30000200 1.1.1.1	Configure the VC for PE-1. In this example, VPLS-200-3 is the VC name, 30000200 is the VC ID, and 1.1.1.1 is the VC endpoint IP address.

PE-3

#configure terminal	Enter configure mode.
(config)# mpls l2-circuit VPLS-100-1 10000100 1.1.1.1 mode tagged	Configure the VC for PE-1. In this example, VPLS-100-1 is the VC name, 10000100 is the VC ID, and 1.1.1.1 is the VC endpoint IP address.

Bind Customer Interface to VC

PE-1

#configure terminal	Enter configure mode.
(config)# mpls l2-circuit VPLS-100-1 10000100 3.3.3.3	Configure the VC for PE-3. In this example, VPLS-100-1 is the VC name, 10000100 is the VC ID, and 3.3.3.3 is the VC endpoint IP address.
(config-pseudowire)# mpls l2-circuit VPLS-200-3 30000200 2.2.2.2	Configure the VC for PE-2. In this example, VPLS-200-3 is the VC name, 30000200 is the VC ID, and 2.2.2.2 is the VC endpoint IP address.
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#interface xe9.10 switchport	Creates a L2 sub-interface as xe9.10
(config-if)#encapsulation dot1q 10	Configure the encapsulation as dot1q matching vlan 10
(config-if)#access-if-vpws	Configure access-if-vpws on interface mode
(config-acc-if-vpws)#mpls-l2-circuit VPLS-200-3 primary	Configure the VC for PE-1 In this example, VPLS-200-3 is the VC name
(config-acc-if-vpws)#mpls-l2-circuit VPLS-100-1 secondary	Configure the VC for PE-1 In this example, VPLS-200-3 is the VC name
(config-acc-if-vpws)#vc-mode revertive	Configured the vc-mode revertive

PE-2

#configure terminal	Enter configure mode.
(config)# mpls l2-circuit VPLS-200-3 30000200 1.1.1.1	Configure the VC for PE-1. In this example, VPLS-200-3 is the VC name, 30000200 is the VC ID, and 1.1.1.1 is the VC endpoint IP address.
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#interface xe9.10 switchport	Creates a L2 sub-interface as xe9.10
(config-if)#encapsulation dot1q 10	Configure the encapsulation as dot1q matching vlan 10
(config-if)#access-if-vpws	Configure access-if-vpws on interface mode
(config-acc-if-vpws)#mpls-l2-circuit VPLS-200-3 primary	Configure the VC for PE-12 In this example, VPLS-200-3 is the VC name.

PE-3

#configure terminal	Enter configure mode.
(config)# mpls l2-circuit VPLS-200-3 30000200 1.1.1.1	Configure the VC for PE-1. In this example, VPLS-200-3 is the VC name, 30000200 is the VC ID, and 1.1.1.1 is the VC endpoint IP address.
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#interface xe6.100 switchport	Creates a L2 sub-interface as xe6.100

(config-if)#encapsulation dot1q 100	Configure the encapsulation as dot1q matching vlan 100
(config-if)#access-if-vpws	Configure access-if-vpws on interface mode
(config-acc-if-vpws)# mpls-l2-circuit VPLS-100-1 primary	Configure the VC for PE-12 In this example, VPLS-100-1 is the VC name

Validation

```
PE1#sh ldp session
```

```
Codes: m - MD5 password is not set/unset.
```

```
g - GR configuration not set/unset.
```

```
t - TCP MSS not set/unset.
```

```
Session has to be cleared manually
```

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	2.2.2.2	xe6	Passive	OPERATIONAL	30	02:30:38
	3.3.3.3	xe1	Passive	OPERATIONAL	30	02:30:40
	5.5.5.5	xe1	Passive	OPERATIONAL	30	02:30:38
	4.4.4.4	xe6	Passive	OPERATIONAL	30	02:30:38

```
PE1#
```

```
PE1#sh ip ospf neighbor
```

```
Total number of full neighbors: 2
```

```
OSPF process 100 VRF(default):
```

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
5.5.5.5 0	1	Full/DR	00:00:30	20.20.20.2	xe1
4.4.4.4	1	Full/Backup	00:00:36	40.1.1.2	xe6

0

PE1#

Use the show ldp mpls-l2-circuit (Control Plane) command, and the show mpls vc-table (Forwarding Plane) command, to display complete information about the Layer 2 VC.

If the VC State is UP in the output from the show ldp mpls-l2 circuit command, and the Status is Active in the output of the show mpls vc-table command, a ping from CE1 to CE2 should be successful.

PE1#show ldp mpls-l2-circuit

Transport	Client	VC	VC	Local	Remote	Destination
VC ID	Binding	State	Type	VC Label	VC Label	Address
30000200	xe9.10	UP	Ethernet VLAN	26881	26880	2.2.2.2
10000100	xe9.10	UP	Ethernet VLAN	26880	26880	3.3.3.3

PE1#

PE1#

PE1#sh mpls vc-table

(m) - Service mapped over multipath transport

(e) - Service mapped over LDP ECMP

VC-ID	Vlan-ID	Inner-Vlan-ID	Access-Intf	Network-Intf	Out Label	Tunnel-
Label	Nexthop	Status	UpTime			
10000100	N/A	N/A	xe9.10	-	26880	N/A
3.3.3.3		Inactive	-			
30000200	N/A	N/A	xe9.10	xe6	26880	52480
2.2.2.2		Active	02:35:05			

PE1#

PE1#

PE2#sh ldp session

Codes: m - MD5 password is not set/unset.

g - GR configuration not set/unset.

t - TCP MSS not set/unset.

Session has to be cleared manually

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	1.1.1.1	xe33	Active	OPERATIONAL	30	02:37:16
	4.4.4.4	xe33	Passive	OPERATIONAL	30	02:43:19

PE2#

PE2#

PE2#sh ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
4.4.4.4	1	Full/DR	00:00:38	50.1.1.2	xe33	0

PE2#

PE2#

PE2#

PE2#sh mpls vc-table

(m) - Service mapped over multipath transport

(e) - Service mapped over LDP ECMP

VC-ID Label	Vlan-ID Nexthop	Inner-Vlan-ID Status	Access-Intf UpTime	Network-Intf	Out Label	Tunnel-
30000200	N/A	N/A	xe9.10	xe33	26881	52481
1.1.1.1		Active	02:37:30			

PE2#

PE2#

PE2#

PE3#sh ldp session

Codes: m - MD5 password is not set/unset.

g - GR configuration not set/unset.

t - TCP MSS not set/unset.

Session has to be cleared manually

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	1.1.1.1	xe6	Active	OPERATIONAL	30	02:38:00
	5.5.5.5	xe6	Passive	OPERATIONAL	30	02:43:52

PE3#

PE3#

PE3#sh ip ospf nei

PE3#sh ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
5.5.5.5	1	Full/DR	00:00:36	70.1.1.1	xe6	0

PE3#

PE3#

PE3#

PE3#sh mpls vc-table

(m) - Service mapped over multipath transport

(e) - Service mapped over LDP ECMP

VC-ID Label	Vlan-ID Nexthop	Inner-Vlan-ID Status	Access-Intf UpTime	Network-Intf	Out Label	Tunnel-
10000100	N/A	N/A	xe6.100	-	26880	N/A
1.1.1.1	Inactive	-				

PE3#

PE3#

P1#sh ip ospf neighbor

Total number of full neighbors: 2

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
1.1.1.1	1	Full/DR	00:00:32	40.1.1.1	xe1/1	0
2.2.2.2	1	Full/Backup	00:00:31	50.1.1.1	xe33	0

P1#

P1#

P1#s

% Incomplete command.

P1#

P1#sh ldp session

Codes: m - MD5 password is not set/unset.

g - GR configuration not set/unset.

t - TCP MSS not set/unset.

Session has to be cleared manually

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	1.1.1.1	xe1/1	Active	OPERATIONAL	30	02:40:25
	2.2.2.2	xe33	Active	OPERATIONAL	30	02:46:28

P1#

P2#sh ldp session

Codes: m - MD5 password is not set/unset.

g - GR configuration not set/unset.

t - TCP MSS not set/unset.

Session has to be cleared manually

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	1.1.1.1	xe47	Active	OPERATIONAL	30	02:40:56

3.3.3.3	xe6	Active	OPERATIONAL	30	02:46:49
---------	-----	--------	-------------	----	----------

P2#

P2#sh ip ospf neighbor

Total number of full neighbors: 2

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
1.1.1.1	1	Full/Backup	00:00:35	20.20.20.1	xe47	0
3.3.3.3	1	Full/Backup	00:00:32	70.1.1.2	xe6	0

P2#(config-if)#mpls-l2-circuit t2 service- template ST1

CHAPTER 20 Deep Packet Inspection

Overview

Deep Packet Inspection (DPI) performs a granular check on the inner headers beyond the MPLS bottom of the label stack (BOS) to load-balance the network traffic. The load balancing key is generated after deep analysis of the MPLS header.

The DPI can be configured in the Qumran1 series platforms, and a system reboot is required after enabling and disabling the feature. In Qumran2 series platforms, it is always enabled by default.

Benefits

The DPI feature optimizes network performance by preventing traffic congestion by distributing traffic across available pathways.

Configuration

This section shows the configuration of the DPI.

Topology

In this topology, the traffic flows from one Provider Edge (PE1) to another Provider Edge router (PE2) through a transit Provider router (P). From P to PE2, there is a Link Aggregation Group (LAG) consisting of xe3, xe5, and xe6 and a physical interface connection through xe15. When DPI is enabled, the traffic is load-balanced through the ECMP next-hops po and (xe15) and also among the LAG member ports (xe3, xe5, and xe6).

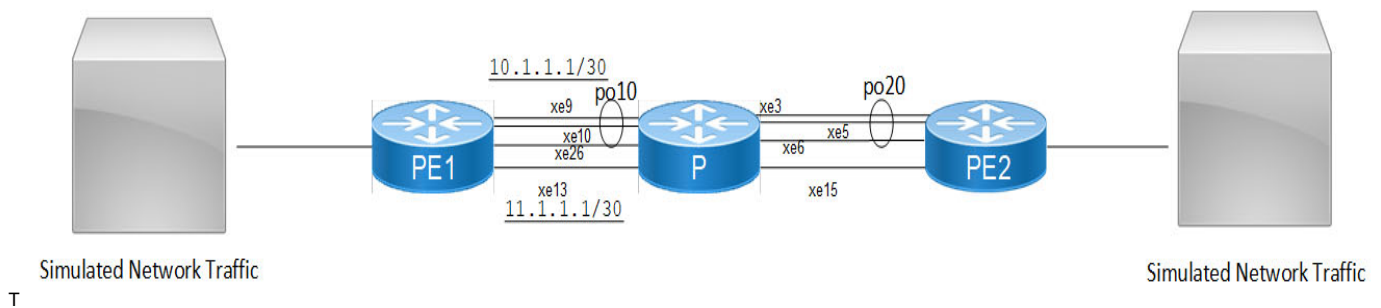


Figure 20-10: DPI Configuration

Configuring DPI

Follow the steps to configure the DPI on Qumran1 series platforms.

PE1

1. Configure IP address secondary on loopback.

```
(config)#interface lo
(config-if)#ip address 3.3.3.3/32 secondary
```


2. Configure prefix SID on the loopback interface to add the prefix SID global block to forward the packet.

```
(config)#interface lo
(config-if)#prefix-sid index 3 no-php
```

3. Configure the ISIS on the node with some paths having the Link Aggregation Group (LAG) member port. This allows the DPI feature to run on the LAG member ports.

```
(config)#interface po10
(config-if)#load-interval 30
(config-if)#ip address 10.1.1.1/30
(config-if)#mtu 9216
(config-if)#label-switching
(config-if)#ip router isis 1
(config-if)#isis wide-metric 50
(config-if)#exit
(config)#interface xe9
(config-if)#channel-group 10 mode active
(config-if)#exit
(config)#interface xe10
(config-if)#channel-group 10 mode active
(config-if)#exit
(config)#interface xe26
(config-if)#channel-group 10 mode active
(config-if)#exit
```

4. Configure the ISIS on the physical interface.

```
(config)#interface xe13
(config-if)#load-interval 30
(config-if)#ip address 11.1.1.1/30
(config-if)#mtu 9216
(config-if)#label-switching
(config-if)#ip router isis 1
(config-if)#isis wide-metric 50
```

5. Configure router ISIS on the loopback interface to advertise it.

```
(config-if)#interface lo
(config-if)#ip router isis 1
(config-if)#exit
```

6. Configure the router ISIS sessions to establish the neighborhood between the routers.

```
(config)#router isis 1
(config-router)#is-type level-1-2
(config-router)#metric-style wide
(config-router)#mpls traffic-eng router-id 3.3.3.3
(config-router)#mpls traffic-eng level-1
(config-router)#mpls traffic-eng level-2
(config-router)#capability cspf
(config-router)#bfd all-interfaces
(config-router)#net 49.0001.0000.0001.0003.00
(config-router)#passive-interface lo
```

7. Enable the Segment Routing (SR), SR entropy, and Topology Independent Loop Free Alternate (TILFA).

```
(config)#router isis 1
(config-router)#fast-reroute ti-lfa level-1 proto ipv4
(config-router)#fast-reroute ti-lfa level-2 proto ipv4
(config-router)#isis segment-routing global block 20000 23000
(config-router)#segment-routing entropy-label
(config-router)#segment-routing mpls
```

8. Configure any of the MPLS services. In this configuration, we are configuring L3VPN service.

```
(config)#ip vrf 1001
(config-vrf)#rd 3.3.3.3:1001
(config-vrf)#route-target both 1001:1001
(config-vrf)#exit
(config)#interface xe6.1001
(config-if)#encapsulation dot1q 1001
(config-if)#load-interval 30
(config-if)#ip vrf forwarding 1001
(config-if)#ip address 201.1.1.1/24
(config-if)#ipv6 address 201::1/64
(config-if)#mtu 9216
(config-if)#exit
(config)#router bgp 65010
(config-router)#bgp router-id 3.3.3.3
(config-router)#neighbor 6.6.6.6 remote-as 65010
(config-router)#neighbor 6.6.6.6 update-source lo
(config-router)#address-family vpnv4 unicast
(config-router-af)#neighbor 6.6.6.6 activate
(config-router-af)#exit-address-family
(config-router)# address-family vpnv6 unicast
(config-router-af)#neighbor 6.6.6.6 activate
(config-router-af)exit-address-family
(config-router)#address-family ipv4 vrf 1001
(config-router-af)redistribute connected
(config-router-af)neighbor 201.1.1.2 remote-as 65011
(config-router-af)neighbor 201.1.1.2 activate
(config-router-af)exit-address-family
(config-router)#address-family ipv6 vrf 1001
(config-router-af)#redistribute connected
(config-router-af)#neighbor 201::2 remote-as 65011
(config-router-af)#neighbor 201::2 activate
(config-router-af)#exit-address-family
```

9. Enable the SR Equi-Cost-Multiple-Path (ECMP) Forwarding Table Notification (FTN) to load-balance the traffic within the LAG and physical ports.

```
(config)#mpls ftn-ecmp sr
```

10. Enable the DPI on Qumran1 series platforms.

```
(config)#advanced parser enable
```

Note: DPI is enabled by default on Qumran2 series platforms.

P

1. Configure IP address secondary on the loopback.

```
P(config)#interface lo
(config-if)#ip address 2.2.2.2/32 secondary
```

2. Configure prefix SID on the loopback interface to add the prefix SID global block to forward the packet.

```
(config)#interface lo
(config-if)#prefix-sid index 2 no-php
```

3. Configure the ISIS on the node with some paths having the Link Aggregation Group (LAG) member port. This allows the DPI feature to run on the LAG member ports.

```
(config)#interface po10
(config-if)#load-interval 30
(config-if)#ip address 10.1.1.2/30
```

```
(config-if)#mtu 9216
(config-if)#label-switching
(config-if)#ip router isis 1
(config-if)#isis wide-metric 50
(config-if)#exit
(config)#interface xe9
(config-if)#channel-group 10 mode active
(config-if)#exit
(config)#interface xe10
(config-if)#channel-group 10 mode active
(config-if)#exit
(config)#interface xe26
(config-if)#channel-group 10 mode active
(config-if)#exit
```

4. Configure the ISIS on the physical interface.

```
(config)#interface xe13
(config-if)#load-interval 30
(config-if)#ip address 11.1.1.2/30
(config-if)#mtu 9216
(config-if)#label-switching
(config-if)#ip router isis 1
(config-if)#isis wide-metric 50
```

5. Configure router ISIS on the loopback interface to advertise it.

```
(config-if)#interface lo
(config-if)#ip router isis 1
(config-if)#exit
```

6. Configure the router ISIS sessions to establish the neighborhood between the routers.

```
(config)#router isis 1
(config-router)#is-type level-1-2
(config-router)#metric-style wide
(config-router)#mpls traffic-eng router-id 2.2.2.2
(config-router)#mpls traffic-eng level-1
(config-router)#mpls traffic-eng level-2
(config-router)#capability cspf
(config-router)#bfd all-interfaces
(config-router)#net 49.0001.0000.0001.0002.00
(config-router)#passive-interface lo
```

7. Enable the SR, SR entropy, and TILFA.

```
(config)#router isis 1
(config-router)#fast-reroute ti-lfa level-1 proto ipv4
(config-router)#fast-reroute ti-lfa level-2 proto ipv4
(config-router)#isis segment-routing global block 20000 23000
(config-router)#segment-routing entropy-label
(config-router)#segment-routing mpls
```

8. Enable the SR ECMP Incoming Label Map (ILM).

```
(config)#mpls ilm-ecmp sr
```

9. Enable the DPI on Qumran1 series platforms.

```
(config)#advanced parser enable
```

Note: DPI is enabled by default on Qumran2 series platforms.

PE2

1. Configure IP address secondary on the loopback interface

```
(config)#interface lo
(config-if)#ip address 6.6.6.6/32 secondary
```

2. Configure prefix SID on the loopback interface to add the prefix SID global block to forward the packet.

```
(config)#interface lo
(config-if)#prefix-sid index 6 no-php
```

3. Configure the ISIS on the node with some paths having the Link Aggregation Group (LAG) member port. This allows the DPI feature to run on the LAG member ports.

```
(config)#interface po20
(config-if)#load-interval 30
(config-if)#ip address 12.1.1.2/30
(config-if)#mtu 9216
(config-if)#label-switching
(config-if)#ip router isis 1
(config-if)#isis wide-metric 100
(config-if)#exit
(config)#interface xe3
(config-if)#channel-group 10 mode active
(config-if)#exit
(config)#interface xe5
(config-if)#channel-group 10 mode active
(config-if)#exit
(config)#interface xe6
(config-if)#channel-group 10 mode active
(config-if)#exit
```

4. Configure the ISIS on the physical interface.

```
(config)#interface xe15
(config-if)#load-interval 30
(config-if)#ip address 13.1.1.2/30
(config-if)#mtu 9216
(config-if)#label-switching
(config-if)#ip router isis 1
(config-if)#isis wide-metric 100
```

5. Configure router ISIS on the loopback interface to advertise it.

```
(config-if)#interface lo
(config-if)#ip router isis 1
(config-if)#exit
```

6. Configure the router ISIS sessions to establish the neighborhood between the routers.

```
(config)#router isis 1
(config-router)#is-type level-1-2
(config-router)#metric-style wide
(config-router)#mpls traffic-eng router-id 6.6.6.6
(config-router)#mpls traffic-eng level-1
(config-router)#mpls traffic-eng level-2
(config-router)#capability cspf
(config-router)#bfd all-interfaces
(config-router)#net 49.0001.0000.0001.0006.00
(config-router)#passive-interface lo
```

7. Enable the SR, SR entropy, and TILFA.

```
(config)#router isis 1
```

```
(config-router)#fast-reroute ti-lfa level-1 proto ipv4
(config-router)#fast-reroute ti-lfa level-2 proto ipv4
(config-router)#isis segment-routing global block 20000 23000
(config-router)#segment-routing entropy-label
(config-router)#segment-routing mpls
```

8. Configure any of the MPLS services. In this configuration, we are configuring L3VPN service.

```
(config)#ip vrf 1001
(config-vrf)#rd 6.6.6.6:1001
(config-vrf)#route-target both 1001:1001
(config-vrf)#exit
(config)#interface xe2.1001
(config-if)#encapsulation dot1q 1001
(config-if)#load-interval 30
(config-if)#ip vrf forwarding 1001
(config-if)#ip address 101.1.1.1/24
(config-if)#ipv6 address 101::1/64
(config-if)#mtu 9216
(config-if)#exit
(config)#router bgp 65010
(config-router)#bgp router-id 6.6.6.6
(config-router)#neighbor 3.3.3.3 remote-as 65010
(config-router)#neighbor 3.3.3.3 update-source lo
(config-router)#address-family vpnv4 unicast
(config-router-af)#neighbor 3.3.3.3 activate
(config-router-af)#exit-address-family
(config-router)#address-family vpnv6 unicast
(config-router-af)#neighbor 3.3.3.3 activate
(config-router-af)#exit-address-family
(config-router)#address-family ipv4 vrf 1001
(config-router-af)#redistribute connected
(config-router-af)#neighbor 101.1.1.2 remote-as 65011
(config-router-af)#neighbor 101.1.1.2 activate
(config-router-af)#exit-address-family
(config-router)# address-family ipv6 vrf 1001
(config-router-af)#redistribute connected
(config-router-af)#neighbor 101::2 remote-as 65011
(config-router-af)#neighbor 101::2 activate
(config-router-af)#exit-address-family
```

9. Enable the SR ECMP FTN to load-balance the traffic within the LAG and physical ports.

```
(config)#mpls ftn-ecmp sr
```

10. Enable the DPI on Qumran1 series platforms.

```
(config)#advanced parser enable
```

Note: DPI is enabled by default on Qumran2 series platforms.

Running configurations

The running configuration for the PE1 is as follows:

```
#show running-config
!
mpls ftn-ecmp sr
!
ip vrf 1001
```

```
rd 3.3.3.3:1001
route-target both 1001:1001
!
interface po10
load-interval 30
ip address 10.1.1.1/30
mtu 9216
label-switching
ip router isis 1
isis wide-metric 50
!
interface lo
ip address 127.0.0.1/8
ip address 3.3.3.3/32 secondary
ipv6 address ::1/128
prefix-sid index 3 no-php
!
interface xe6.1001
encapsulation dot1q 1001
load-interval 30
ip vrf forwarding 1001
ip address 201.1.1.1/24
ipv6 address 201::1/64
mtu 9216
!
interface xe9
channel-group 10 mode active
!
interface xe10
channel-group 10 mode active
!
interface xe13
load-interval 30
ip address 11.1.1.1/30
mtu 9216
label-switching
ip router isis 1
isis wide-metric 50
!
interface xe26
channel-group 10 mode active
!
router isis 1
is-type level-1-2
metric-style wide
mpls traffic-eng router-id 3.3.3.3
mpls traffic-eng level-1
mpls traffic-eng level-2
capability cspf
fast-reroute ti-lfa level-1 proto ipv4
fast-reroute ti-lfa level-2 proto ipv4
bfd all-interfaces
net 49.0001.0000.0001.0003.00
passive-interface lo
isis segment-routing global block 20000 23000
segment-routing entropy-label
segment-routing mpls
```

```

!
router bgp 65010
  bgp router-id 3.3.3.3
  neighbor 6.6.6.6 remote-as 65010
  neighbor 6.6.6.6 update-source lo
  !
  address-family vpnv4 unicast
  neighbor 6.6.6.6 activate
  exit-address-family
  !
  address-family vpnv6 unicast
  neighbor 6.6.6.6 activate
  exit-address-family
  !
  address-family ipv4 vrf 1001
  redistribute connected
  neighbor 201.1.1.2 remote-as 65011
  neighbor 201.1.1.2 activate
  exit-address-family
  !
  address-family ipv6 vrf 1001
  redistribute connected
  neighbor 201::2 remote-as 65011
  neighbor 201::2 activate
  exit-address-family

```

The running configuration for the P is as follows:

```

advanced parser enable
!
mpls ilm-ecmp sr
!
interface po10
  load-interval 30
  ip address 10.1.1.2/30
  mtu 9216
  label-switching
  ip router isis 1
  isis wide-metric 50
!
interface po20
  load-interval 30
  ip address 12.1.1.1/30
  mtu 9216
  label-switching
  ip router isis 1
  isis wide-metric 100
!
interface lo
  ip address 127.0.0.1/8
  ip address 2.2.2.2/32 secondary
  ipv6 address ::1/128
  prefix-sid index 2 no-php
  ip router isis 1
!
interface xe3
  channel-group 20 mode active

```

```

!
interface xe5
  channel-group 20 mode active
!
interface xe6
  channel-group 20 mode active
!
interface xe9
  channel-group 10 mode active
!
interface xe10
  channel-group 10 mode active
!
interface xe13
  load-interval 30
  ip address 11.1.1.2/30
  mtu 9216
  label-switching
  ip router isis 1
  isis wide-metric 50
!
interface xe15
  load-interval 30
  ip address 13.1.1.1/30
  mtu 9216
  label-switching
  ip router isis 1
  isis wide-metric 100
!
interface xe26
  channel-group 10 mode active
!
router isis 1
  is-type level-1-2
  metric-style wide
  mpls traffic-eng router-id 2.2.2.2
  mpls traffic-eng level-1
  mpls traffic-eng level-2
  capability cspf
  fast-reroute ti-lfa level-1 proto ipv4
  fast-reroute ti-lfa level-2 proto ipv4
  bfd all-interfaces
  net 49.0001.0000.0001.0002.00
  passive-interface lo
  isis segment-routing global block 20000 23000
  segment-routing entropy-label
  segment-routing mpls

```

The running configuration for the PE2 is as follows:

```

mpls ftn-ecmp sr
!
ip vrf 1001
  rd 6.6.6.6:1001
  route-target both 1001:1001
!
interface po20
  load-interval 30

```



```
ip address 12.1.1.2/30
mtu 9216
label-switching
ip router isis 1
isis wide-metric 100
!
interface lo
ip address 127.0.0.1/8
ip address 6.6.6.6/32 secondary
ipv6 address ::1/128
prefix-sid index 6 no-php
ip router isis 1
!
interface xe2.1001
encapsulation dot1q 1001
load-interval 30
ip vrf forwarding 1001
ip address 101.1.1.1/24
ipv6 address 101::1/64
mtu 9216
!
interface xe3
channel-group 20 mode active
!
interface xe5
channel-group 20 mode active
!
interface xe6
channel-group 20 mode active
!
interface xe15
load-interval 30
ip address 13.1.1.2/30
mtu 9216
label-switching
ip router isis 1
isis wide-metric 100
!
router isis 1
is-type level-1-2
metric-style wide
mpls traffic-eng router-id 6.6.6.6
mpls traffic-eng level-1
mpls traffic-eng level-2
capability cspf
fast-reroute ti-lfa level-1 proto ipv4
fast-reroute ti-lfa level-2 proto ipv4
bfd all-interfaces
net 49.0001.0000.0001.0006.00
passive-interface lo
isis segment-routing global block 20000 23000
segment-routing entropy-label
segment-routing mpls
!
router bgp 65010
bgp router-id 6.6.6.6
neighbor 3.3.3.3 remote-as 65010
```

```

neighbor 3.3.3.3 update-source lo
!
address-family vpnv4 unicast
neighbor 3.3.3.3 activate
exit-address-family
!
address-family vpnv6 unicast
neighbor 3.3.3.3 activate
exit-address-family
!
address-family ipv4 vrf 1001
redistribute connected
neighbor 101.1.1.2 remote-as 65011
neighbor 101.1.1.2 activate
exit-address-family
!
address-family ipv6 vrf 1001
redistribute connected
neighbor 101::2 remote-as 65011
neighbor 101::2 activate
exit-address-family
!

```

Validation

Validate the show output after configuration as shown below.

PE1

OcNOS#show clns neighbors

```

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 2
Total number of adjacencies: 4
Tag 1: VRF : default
System Id      Interface  SNPA              State  Holdtime  Type Protocol
0000.0001.0002 xe13      80a2.35ec.d66f    Up     26        L1   IS-IS
                po10      80a2.35ec.d699    Up     20        L1   IS-IS
                po10      80a2.35ec.d699    Up     20        L2   IS-IS

```

PE1#show mpls ilm-table

```

Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
S - SNMP, L - LDP, R - RSVP, C - CRLDP
B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
P - SR Policy, U - unknown

```

ILM-ECMP LDP: Disabled, SR: Disabled

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF	Nexthop	pri	UpTime
i>	3.3.3.3/32	5	20003	Nolabel	N/A	N/A	127.0.0.1	Yes	00:06:41
i>	2.2.2.2/32	2	20002	20002	N/A	xe13	11.1.1.2	Yes	00:00:47
			20002	3	N/A	po10	10.1.1.2	No	-
			20002	20002	N/A	po10	10.1.1.2	Yes	-
			20002	3	N/A	xe13	11.1.1.2	No	-
i>	11.1.1.2/32	1	25600	3	N/A	xe13	11.1.1.2	Yes	00:00:47
			25600	20002	N/A	po10	10.1.1.2	No	-
i>	6.6.6.6/32	3	20006	20006	N/A	xe13	11.1.1.2	Yes	00:00:47
			20006	20006	N/A	po10	10.1.1.2	No	-
			20006	20006	N/A	po10	10.1.1.2	Yes	-
			20006	20006	N/A	xe13	11.1.1.2	No	-

i>	10.1.1.2/32	4	25601	3	N/A	po10	10.1.1.2	Yes	00:00:44
			25601	20002	N/A	xe13	11.1.1.2	No	-

PE1#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed

CreateTime: 00:07:47, UpTime: 00:07:47, LastUpdate: 00:07:34

Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 2 refcount: 1

Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 2, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: xe13, out label: 20002

Nexthop addr: 11.1.1.2 cross connect ix: 4, op code: Push

Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 19 bypass ftn-ix: 4

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 19, owner: N/A, Stale: NO, refcount: 4, out intf: po10, out label: 3

Nexthop addr: 10.1.1.2 cross connect ix: 1, op code: Push

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3 refcount: 1

Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 3, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: po10, out label: 20002

Nexthop addr: 10.1.1.2 cross connect ix: 4, op code: Push

Backup Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 17 bypass ftn-ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 17, owner: N/A, Stale: NO, refcount: 4, out intf: xe13, out label: 3

Nexthop addr: 11.1.1.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active, Tunnel-Policy: N/A, State: Installed

CreateTime: 00:07:39, UpTime: 00:07:39, LastUpdate: N/A

Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 2201, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 2 refcount: 1

Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 2, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: xe13, out label: 20002

Nexthop addr: 11.1.1.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 2.2.2.2/32, id: 4, row status: Active, Tunnel-Policy: N/A, State: Installed

CreateTime: 00:07:39, UpTime: 00:07:39, LastUpdate: N/A

Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 2202, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3 refcount: 1

Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 3, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: po10, out label: 20002

Nexthop addr: 10.1.1.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 6.6.6.6/32, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed

CreateTime: 00:07:47, UpTime: 00:07:47, LastUpdate: 00:07:34

Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0

Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 21 refcount: 1

Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 21, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: xe13, out label: 20006

Nexthop addr: 11.1.1.2 cross connect ix: 3, op code: Push

Backup Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 9 bypass ftn-ix: 4

Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 9, owner: ISIS-SR, Stale: NO, refcount: 8, out intf: po10, out label: 20006

Nexthop addr: 10.1.1.2 cross connect ix: 3, op code: Push

Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 9 refcount: 1

Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up

```
State: Active
  Out-segment with ix: 9, owner: ISIS-SR, Stale: NO, refcount: 8, out intf: po10, out label: 20006
Nexthop addr: 10.1.1.2      cross connect ix: 3, op code: Push

Backup Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 21 bypass ftn-ix: 3
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
State: Active
  Out-segment with ix: 21, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: xe13, out label: 20006
Nexthop addr: 11.1.1.2      cross connect ix: 3, op code: Push

PE1#
PE1#show mpls vrf-forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup, B - BGP FTN
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP or SR ECMP

Code   FEC                FTN-ID VRF-ID   Nhlfe-ID   Pri   Out-Label   Out-Intf       Nexthop       UpTime
B> 101.1.1.0/24        2      2      4          Yes  25600      -              6.6.6.6       00:02:07
B> 101::/64           1      2      4          Yes  25600      -              6.6.6.6       00:02:07
PE1#show mpls vrf-table
Output for IPv4 VRF table with id: 2 (fib_id: 2)
Primary FTN entry with FEC: 101.1.1.0/24, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed
CreateTime: 00:02:12, UpTime: 00:02:12, LastUpdate: N/A
Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
VRF id 2, FIB id 2, BGP peer 6.6.6.6 BGP prefix 101.1.1.0
Transport Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 4 refcount: 2
Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: BGP, Stale: NO, refcount: 1, BGP out intf: xe13, transport out intf: xe13, out label:
25600
Nexthop addr: 6.6.6.6      cross connect ix: 7, op code: Push and Lookup

Output for IPv6 VRF table with id: 2 (fib_id: 2)
Primary FTN entry with FEC: 101::/64, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
CreateTime: 00:02:12, UpTime: 00:02:12, LastUpdate: N/A
Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
VRF id 2, FIB id 2, BGP peer 606:606:: BGP prefix 101::
Transport Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 4 refcount: 2
Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: BGP, Stale: NO, refcount: 1, BGP out intf: xe13, transport out intf: xe13, out label:
25600
Nexthop addr: 6.6.6.6      cross connect ix: 7, op code: Push and Lookup
PE1#show etherchannel summary
Aggregator po10 100010
Aggregator Type: Layer3
Admin Key: 0010 - Oper Key 0010
Link: xe9 (10030) sync: 1
Link: xe10 (10031) sync: 1
Link: xe26 (10047) sync: 1
PE1#show int counters rate mbps
+-----+-----+-----+-----+-----+
| Interface | Rx mbps | Rx pps | Tx mbps | Tx pp |
+-----+-----+-----+-----+-----+
po10        46.72    4146    93.44    8279
xe6         42.79    3820    19.62    1751
xe6.1001    200.52    17892   91.88    8203
xe9         16.12    1430    28.98    2566
xe10        15.13    1343    29.60    2623
xe13        44.09    3906    87.51    7747
xe26        15.47    1372    34.86    3089

P

OcNOS#show clns neighbors
```

Total number of L1 adjacencies: 4
Total number of L2 adjacencies: 4
Total number of adjacencies: 8
Tag 1: VRF : default

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
0000.0001.0003	xe13	e8c5.7a11.9e64	Up	7	L1	IS-IS
			Up	7	L2	IS-IS
0000.0001.0006	xe15	e8c5.7a8b.5146	Up	8	L1	IS-IS
			Up	8	L2	IS-IS
0000.0001.0003	po10	e8c5.7a11.9e73	Up	8	L1	IS-IS
			Up	8	L2	IS-IS
0000.0001.0006	po20	e8c5.7a8b.5155	Up	7	L1	IS-IS
			Up	7	L2	IS-IS

P#
P#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
S - SNMP, L - LDP, R - RSVP, C - CRLDP
B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
P - SR Policy, U - unknown

ILM-ECMP LDP: Disabled, SR: Enabled

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF	Nexthop	pri	UpTime
i>	11.1.1.1/32	2	25600	3	N/A	xe13	11.1.1.1	Yes	00:01:19
			25600	20003	N/A	po10	10.1.1.1	No	-
i>	3.3.3.3/32	6	20003	20003	N/A	po10	10.1.1.1	Yes	00:01:04
			20003	3	N/A	xe13	11.1.1.1	No	-
			20003	20003	N/A	xe13	11.1.1.1	Yes	-
			20003	3	N/A	po10	10.1.1.1	No	-
i>	2.2.2.2/32	1	20002	Nolabel	N/A	N/A	127.0.0.1	Yes	00:01:40
i>	6.6.6.6/32	7	20006	20006	N/A	po20	12.1.1.2	Yes	00:01:04
			20006	3	N/A	xe15	13.1.1.2	No	-
			20006	20006	N/A	xe15	13.1.1.2	Yes	-
			20006	3	N/A	po20	12.1.1.2	No	-
i>	12.1.1.2/32	4	25602	3	N/A	po20	12.1.1.2	Yes	00:01:17
			25602	20006	N/A	xe15	13.1.1.2	No	-
i>	13.1.1.2/32	3	25601	3	N/A	xe15	13.1.1.2	Yes	00:01:18
			25601	20006	N/A	po20	12.1.1.2	No	-
i>	10.1.1.1/32	5	25603	3	N/A	po10	10.1.1.1	Yes	00:01:16
			25603	20003	N/A	xe13	11.1.1.1	No	-

P#show etherchannel summary
Aggregator po10 100010
Aggregator Type: Layer3
Admin Key: 0010 - Oper Key 0010
Link: xe9 (10009) sync: 1
Link: xe10 (10010) sync: 1
Link: xe26 (10026) sync: 1

Aggregator po20 100020
Aggregator Type: Layer3
Admin Key: 0020 - Oper Key 0020
Link: xe3 (10003) sync: 1
Link: xe5 (10005) sync: 1
Link: xe6 (10006) sync: 1

P#show int counters rate mbps

Interface	Rx mbps	Rx pps	Tx mbps	Tx pp
po10	95.23	8438	47.61	4225
po20	45.30	4018	89.16	7903
xe3	12.12	1073	31.17	2762
xe5	13.75	1220	29.17	2585
xe6	19.44	1725	28.82	2555
xe9	29.54	2615	16.42	1457
xe10	30.16	2673	15.42	1369
xe13	89.18	7895	44.93	3980
xe15	47.31	4188	95.18	8428
xe26	35.52	3148	15.77	1398

PE2

OcNOS#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
 (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled, SR: Enabled

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-Intf	ELC	Nexthop	UpTime
i>	2.2.2.2/32	1	51	-	(e)	-	-	-	-	00:01:40
			1	0	Yes	20002	xe15	Yes	13.1.1.1	-
			4	-	No	3	po20	Yes	12.1.1.1	-
			2	0	Yes	20002	po20	Yes	12.1.1.1	-
			3	-	No	3	xe15	Yes	13.1.1.1	-
i(b)>	2.2.2.2/32	3	2	2201	Yes	20002	po20	No	12.1.1.1	00:01:38
i(b)>	2.2.2.2/32	4	1	2202	Yes	20002	xe15	No	13.1.1.1	00:01:38
i>	3.3.3.3/32	2	53	-	(e)	-	-	-	-	00:01:40
			16	0	Yes	20003	xe15	Yes	13.1.1.1	-
			17	-	No	20003	po20	Yes	12.1.1.1	-
			17	0	Yes	20003	po20	Yes	12.1.1.1	-
			16	-	No	20003	xe15	Yes	13.1.1.1	-

PE2#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
 CreateTime: 00:08:00, UpTime: 00:08:00, LastUpdate: 00:07:39

Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 1 refcount: 1

Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 1, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: xe15, out label: 20002

Nexthop addr: 13.1.1.1 cross connect ix: 5, op code: Push

Backup Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 4 bypass ftn-ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 4, owner: N/A, Stale: NO, refcount: 4, out intf: po20, out label: 3

Nexthop addr: 12.1.1.1 cross connect ix: 3, op code: Push

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 2 refcount: 1

Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 2, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: po20, out label: 20002

Nexthop addr: 12.1.1.1 cross connect ix: 5, op code: Push

Backup Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3 bypass ftn-ix: 4

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 3, owner: N/A, Stale: NO, refcount: 4, out intf: xe15, out label: 3

Nexthop addr: 13.1.1.1 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active, Tunnel-Policy: N/A, State: Installed
 CreateTime: 00:07:58, UpTime: 00:07:58, LastUpdate: N/A

Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 2201, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 2 refcount: 1

Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 2, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: po20, out label: 20002

Nexthop addr: 12.1.1.1 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 2.2.2.2/32, id: 4, row status: Active, Tunnel-Policy: N/A, State: Installed
 CreateTime: 00:07:58, UpTime: 00:07:58, LastUpdate: N/A

Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 2202, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 1 refcount: 1

Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 1, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: xe15, out label: 20002

The DPI feature introduces the following configuration command.

Use this command to enable the DPI on Qumran1 series platforms.

```
advanced parser enable
```

None

None

Configure mode

Introduced in OcNOS version 6.5.3 and applicable to Qumran1 series platforms.

This example shows how to enable the DPI on Qumran1 series platforms:

```
OcNOS#configure terminal
OcNOS#(config)#advanced parser enable
OcNOS#(config)#commit
```

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
ECMP	Equal-Cost-Multiple-Path (ECMP) is a network routing technique that uses multiple paths when the paths have equal cost for packet transfer.
FTN	FEC to NHLFE Map is a networking concept that maps the incoming packet to the relevant routing path using the forwarding table.
ILM	Incoming Label Map (ILM) is a networking concept that checks the incoming packet labels and identifies the appropriate outgoing labels for the next hop.
ISIS	Intermediate System to Intermediate System (IS-IS) is an Interior Gateway Protocol used in computer networks to route data within an autonomous system.
LAG	Link Aggregation Group (LAG) is a collection of multiple network connections into a single logical link. This networking technique enhances bandwidth, provides redundancy, and improves fault tolerance.
MPLS	Multi-Protocol Label Switching (MPLS) is a networking protocol that labels the packet to direct traffic through a network.
MPLS header	MPLS header is a 32-bit header containing 20-bit MPLS label value and other related information.
SR	Segment routing is a technique where the sender of a packet can partially or entirely specify a route in a network through which a packet is sent. It is a form of source routing where nodes and links are represented as segments.
SR entropy	Segment Routing Entropy is a mechanism in SR that enables load-balancing across multiple paths.
TILFA	Topology Independent Loop Free Alternate (TILFA) paths are redundant backup paths that transfer the data packet without looping back to the source.

Multi-Protocol Label Switching Command Reference

CHAPTER 1 MPLS Commands

This chapter is a reference for the MPLS commands:

- [bandwidth](#)
- [control-word](#)
- [clear mpls counters ldp](#)
- [clear mpls counters rsvp](#)
- [clear mpls counters static](#)
- [clear mpls l2-circuit statistics](#)
- [flow-label](#)
- [group-id](#)
- [group-name](#)
- [label-switching](#)
- [manual-pseudowire](#)
- [match vlan](#)
- [mpls ac-group](#)
- [admin-groups](#)
- [mpls bandwidth-class](#)
- [mpls ftn-ecmp ldp](#)
- [mpls ftn-entry tunnel-id](#)
- [mpls ftn-entry](#)
- [mpls ilm-ecmp ldp](#)
- [mpls ilm-entry pop](#)
- [mpls ilm-entry swap](#)
- [mpls ingress-ttl](#)
- [mpls l2-circuit](#)
- [mpls-l2-circuit NAME](#)
- [mpls l2-circuit-fib-entry](#)
- [mpls label mode](#)
- [mpls local-packet-handling](#)
- [mpls lsp-encap-dscp-preserve](#)
- [mpls lsp-model uniform](#)
- [mpls lsp-stitching](#)
- [mpls map-route](#)
- [mpls min-label-value](#)
- [mpls propagate-ttl](#)

- `mpls traffic-eng srlg`
- `ping mpls`
- `secondary srlg-disjoint`
- `secondary-priority srlg-disjoint`
- `service-tpid`
- `rewrite ingress`
- `service-template`
- `show mpls`
- `show admin-groups`
- `show mpls bandwidth-class`
- `show mpls counters ldp`
- `show mpls counters rsvp`
- `show mpls counters static`
- `show mpls cross-connect-table`
- `show mpls cross-connect-table backup`
- `show mpls forwarding-table detail`
- `show mpls forwarding-table`
- `show mpls ftn-table`
- `show mpls ilm-table`
- `show mpls in-segment-table`
- `show mpls l2-circuit`
- `show mpls l2-circuit statistics`
- `show mpls mapped-routes`
- `show mpls out-segment-table`
- `show mpls qos-resource`
- `show mpls vc-table`
- `show mpls vrf`
- `show mpls vrf-forwarding-table vrf`
- `show running-config interface mpls`
- `show running-config mpls`
- `show running-config service-template`
- `show running-config vc`
- `show running-config vpls`
- `show service-template`
- `show vccv statistics`
- `srlg-disjoint`
- `trace mpls`
- `tunnel-id`
- `tunnel-name`

- [tunnel-select-policy](#)
- [vccv cc-type](#)
- [vccv cv-type](#)

bandwidth

Use this command to specify the maximum bandwidth to be used for a band-class. The bandwidth value is in bits.

Note: Run this command in the Bandwidth-class mode (refer to [mpls bandwidth-class](#)).

Command Syntax

```
bandwidth BANDWIDTH setup-priority <0-7> hold-priority <0-7>
```

Parameter

BANDWIDTH	<1-999>k for 1 to 999 kilo bits/s <1-999>m for 1 to 999 mega bits/s <1-100>g for 1 to 100 giga bits/s
setup-priority	Indicate the setup-priority parameter
<0-7>	The actual setup priority value
hold-priority	Indicate the hold-priority parameter
<0-7>	The actual hold priority value

Default

By default, bandwidth priority is 0

Command Mode

Bandwidth-class mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls bandwidth-class new-BC
(config-mpls-bw)#bandwidth 100m setup-priority 1 hold-priority 1
```

control-word

Use this command to enable control word for the MPLS layer-2 virtual circuit.

Use the no parameter with this command to disable control word from the MPLS layer-2 virtual circuit.

Command Syntax:

```
control-word
no control-word
```

Parameters

NA

Default

By default, control-word is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#control-word
```

clear mpls counters ldp

Use this command to clear traffic statistics for FTNs and ILMs configured by LDP.

Command Syntax

```
clear mpls counters ldp ((ftn (|A.B.C.D/M)) | (ilm (|A.B.C.D/M)) |)
```

Parameter

ftn	FEC-to-NHLFE map counters
A.B.C.D/M	FEC prefix
ilm	Incoming label map counters
A.B.C.D/M	FEC prefix

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#clear mpls counters ldp
```

clear mpls counters rsvp

Use this command to clear traffic statistics for LSPs configured by RSVP.

Command Syntax

```
clear mpls counters rsvp ((tunnel-name NAME) | (tunnel-id TUNNEL_ID) | (node-role
    (ingress | transit | egress)) |)
```

Parameter

NAME	RSVP tunnel name
TUNNEL_ID	RSVP tunnel identifier
ingress	LSP role is ingress
transit	LSP role is transit
egress	LSP role is egress

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#clear mpls counters rsvp
```

clear mpls counters static

Use this command to clear traffic statistics for statically configured FTNs and ILMs.

Command Syntax

```
clear mpls counters static ((ftn (|A.B.C.D/M)) | (ilm (|A.B.C.D/M)) |)
```

Parameter

ftn	FEC-to-NHLFE map counters
A.B.C.D/M	FEC prefix
ilm	Incoming label map counters
A.B.C.D/M	FEC prefix

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#clear mpls counters static
```

clear mpls l2-circuit statistics

Use this command to clear MPLS traffic statistics for L2 circuit.

Command Syntax

```
clear mpls l2-circuit NAME statistics(access-port|network-port|)
```

Parameters

name	Name of L2 circuit
access-port	Displays the access port statistics
network-port	Displays the network port statistics

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#clear mpls l2-circuit vcl statistics
```

flow-label

Use this command to enable flow-label transmit, receive or both for the MPLS layer-2 virtual circuit and mpls vpls on dynamic and static VPWS and VPLS.

Use `no` command to disable flow-label transmit, receive or both for the MPLS layer-2 virtual circuit and mpls vpls on dynamic and static VPWS and VPLS.

For signaling flow-label capability in an RFC-compliant (RFC6391/8077) way using "The Pwid FEC Element" = 0x80 when all Interface Parameter Sub-TLV is part of Pwid FEC Element to support interop with other vendors, then `interface-param-tlv` can be used.

Command Syntax

```
flow-label (both|receive|transmit) (static|interface-param-tlv|)
no flow-label (static|interface-param-tlv|)
```

Parameters

<code>both</code>	flow label direction both (transmit and receive)
<code>receive</code>	flow label direction receive
<code>transmit</code>	flow label direction transmit
<code>static</code>	flow-label static
<code>interface-param-tlv</code>	ldp specific interface parameter tlv

Command Mode

config-pseudowire mode and config-vpls mode

Applicability

This command was introduced in OcNOS version 6.0.0 and added parameter `interface-param-tlv` in OcNOS version 6.3.0 to support interop with other vendors.

Example

For the config-pseudowire mode:

```
# configure terminal
(config)#mpls l2-circuit vc1111 1111 7.7.7.7
(config-pseudowire)#flow-label transmit

# configure terminal
(config)#mpls l2-circuit vc1111 1111 7.7.7.7
(config-pseudowire)#no flow-label
```

For the config-vpls mode:

```
# configure terminal
(config)#mpls vpls test 100
(config-vpls)# flow-label both

# configure terminal
(config)#mpls vpls test 100
(config-vpls)# no flow-label
```

For the static configuration:

```
# configure terminal
(config)#mpls l2-circuit vc1111 1111 7.7.7.7
(config-pseudowire)#flow-label transmit static
```

For the config-vpls mode:

```
# configure terminal
(config)#mpls vpls test 100
(config-vpls)# flow-label both static
```

```
# configure terminal
(config)#mpls vpls test 100
(config-vpls)# no flow-label static
```

For the un-configuration of the static flow label:

For the config-pseudowire mode:

```
# configure terminal
(config)#mpls l2-circuit vc1111 1111 7.7.7.7
(config-pseudowire)#no flow-label static
```

group-id

Use this command to configure a specific group identifier to existing group with a group name in the MPLS layer-2 virtual circuit.

Use the no parameter with this command to remove group identifier from the MPLS layer-2 virtual circuit

Command Syntax

```
group-id <1-4294967295>
no group-id
```

Parameters

<1-4294967295> Value for group identifier

Default

By default, group-id is disabled. If group-name is configured, default group-id is the first available identifier.

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#group-name group-1
(config-pseudowire)#group-id 11
```

group-name

Use this command to map the MPLS layer-2 virtual circuit with a specific group.

Use the no parameter with this command to remove group from the MPLS layer-2 virtual circuit

Command Syntax

```
group-name NAME
no group-name
```

Parameters

NAME	String identifying group NAME
------	-------------------------------

Default

By default, group-name is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 6.0.0.

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#group-name group-1
```

label-switching

Use this command to either enable label-switching on an interface or to modify the label-space to which this interface is bound.

Use the `no` parameter and the interface is bound to the platform-wide (zero) label-space.

Note: When label-switching enabled on VLAN interface, MTU value must be manually increased by at least 20 bytes on Parent interfaces of VLAN. Example, default MTU must be set as 1520 instead of 1500 on label-switching parent interface label switched VLAN interface. (Parent Interface MTU \geq label switched VLAN interface MTU + 20).

Command Syntax

```
label-switching
label-switching <0-60000>
no label-switching
```

Parameter

`<0-60000>` Label space value in this range

Default

By default, label switching is disabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows the enabling of label switching on the `eth0` interface.

```
#configure terminal
(config)#interface eth0
(config-if)#label-switching 654
```

manual-pseudowire

Use this command to configure the MPLS layer-2 virtual circuit as manual. This disables the default signalling mode of the MPLS layer-2 virtual circuit.

Use the no parameter with this command to disable manual mode of the MPLS layer-2 virtual circuit & enable signalling mode of the MPLS layer-2 virtual circuit.

Command Syntax

```
manual-pseudowire
no manual-pseudowire
```

Parameters

NA

Default

By default, manual-pseudowire is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#manual-pseudowire
```

match vlan

Use this command to configure a match VLAN action for a service template.

Use the `no` parameter to remove a match VLAN action for a service template.

Command Syntax

```
match (all | double-tag outer-vlan <2-4094> inner-vlan VLAN_RANGE | outer-vlan
    VLAN_RANGE | untagged)
no match (double-tag outer-vlan <2-4094> inner-vlan VLAN_RANGE | outer-vlan
    VLAN_RANGE | untagged)
```

Parameter

<code>all</code>	Accept all matches
<code>double-tag</code>	Double tag match
<code>outer-vlan</code>	Double tag outer VLAN
<code><2-4094></code>	Outer VLAN identifier
<code>inner-vlan</code>	Double tag inner VLAN
<code>VLAN_RANGE</code>	VLAN identifier <2-4094> range: 2-5,10 or 2-5,7-19
<code>outer-vlan</code>	Single tag outer-VLAN
<code>VLAN_RANGE</code>	VLAN identifier <2-4094> range: 2-5,10 or 2-5,7-19
<code>untagged</code>	Match untagged. This parameter depends on the <code>switchport dot1q ethertype</code> configuration. Packets received with a TPID other than 0x8100 (default value) and the TPID value configured by <code>switchport dot1q ethertype</code> are treated as untagged. For example, if you give the command: <code>switchport dot1q ethertype 0x8888</code> then packets received with TPID 0x8100 or 0x88a8 are treated as tagged. Packets received with other TPIDs are treated as untagged.

Command Mode

MPLS SVC mode

Applicability

This command was introduced before OcNOS version 1.3 and updated in OcNOS version 3.0.

The inner vlan range option added in OcNOS version 4.1.

Example

```
#configure terminal
(config)#service-template C2
(config-svc)#match double-tag outer-vlan 10 inner-vlan 20
(config-svc)#exit
(config)#service-template C2
(config-svc)#no match double-tag outer-vlan 10 inner-vlan 20
(config-svc)#exit
#configure terminal
```

```
(config)#service-template C3
(config-svc)#match double-tag outer-vlan 10 inner-vlan 200-300
(config-svc)#exit
(config)#service-template C4
(config-svc)#no match double-tag outer-vlan 10 inner-vlan 200-300
(config-svc)#exit
#configure terminal
(config)#service-template t1
(config-svc)#match untagged
(config-svc)#rewrite ingress push 100
```

mpls ac-group

Use this command to create a new access circuit group for MPLS.

Use the `no` parameter with this command to remove an access circuit group.

Command Syntax

```
mpls ac-group NAME <1-4294967295>
no mpls ac-group NAME
```

Parameter

NAME	The name of the access circuit group
<1-4294967295>	The identifier for the group; used in LDP

Default

By default, mpls ac group is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls ac-group new-ac 123

(config)#no mpls ac-group new-ac
```

admin-groups

Use this command to create a name-to-value binding for an administrative group.

Note: Only 32 administrative groups can be configured at one time.

Use the `no` parameter with this command to remove a named administrative group.

Command Syntax

```
admin-group NAME <0-31>
no admin-group NAME <0-31>
```

Parameters

NAME	Name of administrative group
<0-31>	The value of the administrative group

Default

By default, mpls admin group is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#admin-group mygroup 3
```

mpls bandwidth-class

Use this command to create a new bandwidth class name. Using this command changes the command mode to Bandwidth-class mode.

Use the `no` parameter with this command to remove a bandwidth class name.

Command Syntax

```
mpls bandwidth-class NAME
no mpls bandwidth-class NAME
```

Parameter

NAME	Name of the bandwidth class
------	-----------------------------

Default

By default, mpls bandwidth-class is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls bandwidth-class new-BC
(config-mpls-bw)#

(config)#no mpls bandwidth-class new-BC
```

mpls ftn-ecmp ldp

Use this command to enable Equal-Cost Multi-Path (ECMP) for Label Distribution Protocol (LDP) Forwarding Table Entry (FTN). FTN contains the details of forwarding the labeled packets.

Use `no` command to disable ECMP for LDP FTN.

Command Syntax

```
mpls ftn-ecmp ldp
no mpls ftn-ecmp ldp
```

Parameter

None

Default

Disabled

Command Mode

Configure mode

Applicability

Introduced in OcNOS version 6.4.1.

Examples

The below example shows how to enable and disable ECMP for LDP FTN:

```
#configure terminal
(config)#mpls ftn-ecmp ldp
(config)# commit
(config)# no mpls ftn-ecmp ldp
(config)# commit
```

mpls ftn-entry tunnel-id

This command will be used to create a static tunnel.

In hardware, it creates a logical interface to which services can be mapped.

Note: Only global label space is supported and per interface label space is not supported. MPLS core with IPv6 is not supported.

Command Syntax

```
mpls ftn-entry tunnel-id <1-5000> (A.B.C.D/M|A.B.C.D A.B.C.D) <16-1048575> A.B.C.D
  IFNAME ((secondary|primary)|)

no mpls ftn-entry tunnel-id <1-5000> (A.B.C.D/M|A.B.C.D A.B.C.D) <16-1048575>
  A.B.C.D IFNAME ((secondary|primary)|)

mpls ftn-entry tunnel-id <1-5000> X:X::X:X/M <16-1048575> X:X::X:X IFNAME
  ((secondary|primary)|)

no mpls ftn-entry tunnel-id <1-5000> X:X::X:X/M <16-1048575> X:X::X:X IFNAME
  ((secondary|primary)|)
```

Parameters

<1-5000>	The tunnel ID value
A.B.C.D/M	Forwarding equivalence class with mask
A.B.C.D	Mask for forwarding equivalency class
<16-1048575>	Outgoing label
A.B.C.D	Nexthop IPv4 address
IFNAME	Outgoing interface name
primary	The primary LSP; default is primary
secondary	The secondary LSP Command Mode
X:X::X:X/M	IPv6 Forwarding Equivalence Class with Mask
X:X::X:X	Nexthop IPv6 address

Default

By default, mpls ftn-entry tunnel-id are disabled

Command mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls ftn-entry tunnel-id 2 10.10.0.0/24 16 1.2.3.4 eth1 secondary
(config)#no mpls ftn-entry tunnel-id 2 10.10.0.0/24 16 1.2.3.4 eth1 secondary
```

mpls ftn-entry

Use this command to create a static LSP. In the hardware, this command creates an IP route with outgoing MPLS parameters.

Note: Only global label space is supported and per interface label space is not supported.

Command Syntax

```
mpls ftn-entry (A.B.C.D/M|A.B.C.D A.B.C.D) <16-1048575> A.B.C.D IFNAME
no mpls ftn-entry (A.B.C.D/M|A.B.C.D A.B.C.D) <16-1048575> A.B.C.D IFNAME
```

Parameters

A.D.C.D/M	Forwarding Equivalence Class with Mask
A.B.C.D	Mask for forwarding equivalency class
<16-1048575>	Outgoing label <16-1048575>
A.B.C.D	Nexthop IPv4 address
IFNAME	Outgoing interface name

Default

By default, mpls ftn-entry are disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)# mpls ftn-entry 2.2.2.2/32 111 20.0.0.2 eth1
(config)# no mpls ftn-entry 2.2.2.2/32 111 20.0.0.2 eth1
```

mpls ilm-ecmp ldp

Use this to enable ECMP for LDP Incoming Label Map (ILM).

Use `no` of this to disable ECMP for LDP ILM.

Note: Entropy is also required to be configured for load-balancing to work.

Note: LDP has to be configured with `no-php` for entropy to work (Q1 platforms).

Command Syntax

```
mpls ilm-ecmp ldp
no mpls ilm-ecmp ldp
```

Parameters

None

Default

LDP ECMP on transit nodes is disabled. If LDP load-balancing is required on transit nodes, enable this option.

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 6.1.0.

Example

```
#configure terminal
(config)#mpls ilm-ecmp ldp
(config)#no mpls ilm-ecmp ldp
```

mpls ilm-entry pop

Use this command to create an ILM entry in the ILM table to which a POP incoming interface is bound. Upon receipt of a labeled packet on an MPLS-enabled router, a lookup is done based on the incoming label in the ILM table. If a match is found, the packet may either be label-switched downstream, or popped and passed over IP. In a pop operation, an outgoing label is not needed as is either accepted or forwarded over IP. The nexthop option is also not mandatory because the FEC IP address could be a local IP address.

Use the `no` option with the command to delete an ILM entry. If there is no match, an error message displays.

Note: Only global label space is supported and per interface label space is not supported.

Command Syntax

```
mpls ilm-entry <16-1048575> pop
no mpls ilm-entry <16-1048575> pop
```

Parameters

<16-1048575>	Incoming label value
pop	Pop the incoming label

Default

By default, mpls ilm-entry are disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls ilm-entry 100 pop
```

mpls ilm-entry swap

Use this command to create an ILM entry in the ILM table to which a swap incoming interface is bound. Upon receipt of a labeled packet on an MPLS-enabled router, a lookup is done based on the incoming label in the ILM table. If a match is found, the packet may either be label-switched downstream, or popped and passed over IP.

Use the `no` option with the command to delete an ILM entry. If there is no match, an error message displays.

Note: Only global label space is supported and per interface label space is not supported. MPLS core with IPv6 is not supported.

Command Syntax

```
mpls ilm-entry <16-1048575> swap <16-1048575> IFNAME A.B.C.D (A.B.C.D/M|A.B.C.D
A.B.C.D)
no mpls ilm-entry <16-1048575> swap <16-1048575> IFNAME A.B.C.D (A.B.C.D/M|A.B.C.D
A.B.C.D)
mpls ilm-entry <16-1048575> swap <16-1048575> IFNAME X:X::X:X X:X::X:X/M
no mpls ilm-entry <16-1048575> swap <16-1048575> IFNAME X:X::X:X X:X::X:X/M
```

Parameters

<16-1048575>	Incoming label value range <16-1048575>
swap	Specify swap for the incoming label
<16-1048575>	Configure an outgoing label with a value from <16-1048575>
Note: A value of 2 indicates explicit NULL and a value of 3 indicates implicit NULL.	
IFNAME	Outgoing interface name
A.B.C.D	Nexthop IPv4 address
A.B.C.D	The FEC for which this ILM entry is created
A.B.C.D/M	The FEC for which this ILM entry is created, plus mask
A.B.C.D	A mask for forwarding equivalence class mask
X:X::X:X/M	IPv6 FEC for which this ILM entry is being created, plus mask
X:X::X:X	Nexthop IPv6 address

Default

By default, mpls ilm-entry are disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3 and the incoming interface name parameter `IFNAME` is removed in OcNOS version 6.4.1.

Examples

```
#configure terminal
(config)#mpls ilm-entry 16 swap 17 eth2 1.1.1.1 1.1.1.1/3
```

mpls ingress-ttl

Use this command to set a Time to Live (TTL) value for LSPs for which this LSR is the ingress.

Use the `no` parameter with this command to unset the custom TTL value being used for LSPs for which this LSR is the ingress.

Command Syntax

```
mpls ingress-ttl <0-255>
no mpls ingress-ttl
```

Parameter

<0-255>	Set the TTL value to use
---------	--------------------------

Default

By default, mpls ingress-ttl value is 64

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls ingress-ttl 3
```

mpls l2-circuit

Use this command to create an instance of an MPLS layer 2 virtual circuit, without specifying a group to which the VC belongs. Refer to [group-name](#) for information on how to create an MPLS “with” a specific group. A Layer-2 MPLS Virtual Circuit instance may be bound to any interface on the router; however, only one interface may be bound to a Layer-2 circuit at a time.

Use the `no` parameter with this command to delete an instance of an MPLS Layer-2 Virtual Circuit.

Command Syntax

```
mpls l2-circuit NAME <1-4294967295> A.B.C.D
mpls l2-circuit NAME <1-4294967295> A.B.C.D mode raw
mpls l2-circuit NAME <1-4294967295> A.B.C.D mode tagged
no mpls l2-circuit NAME <1-4294967295> A.B.C.D
```

Parameters

NAME	String identifying the MPLS Layer-2 virtual circuit
<1-4294967295>	A 32-bit identifier to which the L2 circuit name should be mapped
A.B.C.D	IPv4 address for the MPLS L2 virtual circuit end-point

Default

By default, mpls l2-circuit is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
```

mpls-l2-circuit NAME

Use this command in the Interface mode to bind an interface to a MPLS Layer-2 Virtual Circuit created in the configure mode. The qos profiles cos-to-queue and queue-color-to-cos are optional parameters and are configurable dynamically on the virtual circuit by repeating mpls-l2-circuit command along with one or both profile options. In order to dynamically unbind the profile, same command pattern should be repeated by removing the profile which needs to be unbound from the command. Refer 'qos profile' commands from configuration guide for more details about qos profiles.

Use the `no` parameter with this command to delete this instance.

Note: QoS profiles are supported only on vlan based virtual circuits. For port based virtual circuits (service template with match-all option), qos profiles can be bound to interface which will take effect, otherwise default qos profile will take effect. Refer 'qos map-profile' command for binding qos profiles on interface.

Note: For untagged traffic forwarded via port based virtual circuits (service template with match-all option), queue will be 0 by default. In order to assign a non-zero queue for untagged traffic, use 'qos untagged-priority <0-7>' command on the interface.

Note: QoS profile queue-color-to-cos will take effect when MPLS model is uniform. For virtual circuit without rewrite option, 'qos remark-cos' need to be additionally configured to update cos. For virtual circuits with rewrite action pop, cos will always be updated based on qos profile irrespective of the MPLS model.

Command Syntax

```
mpls-l2-circuit NAME service-template NAME ({cos-to-queue NAME | queue-color-to-cos
NAME}) ((primary|secondary))
no mpls-l2-circuit NAME
```

Parameters

NAME	A string identifying the MPLS Layer-2 Virtual Circuit
primary	Identify L2 circuit as the primary link
secondary	Identify L2 circuit as the secondary link; the secondary link is not activated unless the primary link fails
service-template	
	Customer service template
NAME	Name of Customer service template
cos-to-queue	Profile for cos to queue map
NAME	Profile name for cos to queue map
queue-color-to-cos	
	Profile for queue color to cos map
NAME	Profile name for queue color to cos map

Default

By default, mpls l2-circuit is disabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal

(config)#interface eth1
(config-if)#switchport
(config-if)#mpls-l2-circuit vc1 service-template C1

(config-if)#no mpls-l2-circuit vc1

(config)#interface eth2
(config-if)#switchport
(config-if)#mpls-l2-circuit vc2 service-template C2

(config-if)#no mpls-l2-circuit vc2

(config-if)#mpls-l2-circuit vc2 service-template C2
(config-if)#no mpls-l2-circuit vc2

(config)#interface eth2
(config-if)#switchport
(config-if)#mpls-l2-circuit vc2 service-template C2

(config-if)#no mpls-l2-circuit vc2

(config-if)#mpls-l2-circuit vc2 service-template C2
(config-if)#no mpls-l2-circuit vc2
```

mpls l2-circuit-fib-entry

Use this command to add a static Layer-2 MPLS Virtual Circuit FIB entry.

Use the `no` parameter with this command to delete a Layer-2 MPLS Virtual Circuit FIB entry.

Command Syntax

```
mpls l2-circuit-fib-entry VC-ID
mpls l2-circuit-fib-entry VC-ID LABEL LABEL A.B.C.D IFNAME NAME
no mpls l2-circuit-fib-entry VC-ID
```

Parameters

VC-ID	Virtual Circuit ID
LABEL	Incoming label in the range of <16-1048575>
LABEL	Outgoing label in the range of <16-1048585>
A.B.C.D	Nexthop IPv4 address
IFNAME	Provider-facing interface name
NAME	Access interface name or VC to be stitched to.

Default

By default, mpls l2-circuit is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls l2-circuit-fib-entry 10 100 200 10.10.10.10 eth1 eth2
```

mpls label mode

Use this command to configure label allocation mode for VPNv4 and/or VPNv6 routes. Label allocation mode as per-vrf is the default mode in which single mpls-label is allocated for all VPN Routes in a VRF. Label allocation mode as per-prefix will allocate unique mpls-labels per VPN route in a VRF. If allocation model is disabled using no mpls label mode configuration, the configuration reverts back to default-mode .

Label allocation mode is the local property i.e. the VRF routes are distributed to BGP-peer as per the mode configured on local node. When per-vrf mode is configured, single label for all routes in the VRF will be distributed to peer node.

Label allocation mode can be set for all VRFs or selective VRFs by these commands:

```
mpls label mode vpnv4 all-vrfs per-vrf
```

- If the admin selects the per-vrf mode for the entire system, then all VRFs switches to per-vrf allocation mode except for the VRFs that has been explicitly configured using command mpls label mode vpnv4 vrf WORD per-prefix. Label allocation mode set using specific VRF takes precedence over all-vrf command.

```
mpls label mode vpnv6 vrf WORD per-vrf
```

- If the admin selects per-vrf mode for a particular vrf say vrf1, then only vrf1 switches to per-vrf mode and rest of the vrfs will remain in default allocation mode.

Command Syntax

```
mpls label mode (vpnv4|vpnv6|all-afs) (all-vrfs|vrf WORD) (per-prefix|per-vrf)
```

```
no mpls label mode (vpnv4|vpnv6|all-afs) (all-vrfs|vrf WORD) (per-prefix)
```

```
mpls label mode 6pe per-prefix
```

```
no mpls label mode 6pe per-prefix
```

Parameters

vrf WORD	Enter a string to identify the VRF
all-vrfs	All the VRFs
per-prefix	Unique MPLS labels are allocated per VPN route in a VRF
per-vrf	Single MPLS labels are allocated for all VPN routes in a VRF
all-afs	All the address families

Default

By default, per-vrf is enabled.

Command Mode

Configuration mode

Applicability

This command was introduced before OcNOS version 3.0.

Example

```
#configure terminal
(config)#mpls label mode all-afs all-vrfs per-vrf
```

```
(config)#no mpls label mode all-afs all-vrfs
```

```
(config)#mpls label mode 6pe per-prefix
```

```
(config)#no mpls label mode 6pe per-prefix
```

mpls local-packet-handling

Use this command to enable the labeling of locally generated TCP packets. All other locally generated packets are not looked at by the MPLS Forwarder

Use the `no` parameter with this command to disable labeling of locally generated TCP packets.

Command Syntax

```
mpls local-packet-handling
no mpls local-packet-handling
```

Default

By default, mpls local packet handling is disabled

Parameters

None

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls local-packet-handling
```

mpls lsp-encap-dscp-preserve

Use this command to preserve DSCP for IP packets encapsulated into MPLS headers when dscp is remarked on access interface. By default, DSCP is not preserved for IP packets encapsulated into MPLS headers.

Use the no parameter with this to unconfigure DSCP preserve.

Command Syntax

```
mpls lsp-encap-dscp-preserve
no mpls lsp-encap-dscp-preserve
```

Default

By default, mpls local packet handling is disabled

Parameters

None

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 6.5.2.

Examples

```
#configure terminal
(config)#mpls lsp-encap-dscp-preserve
(config)#commit
#configure terminal
(config)#no mpls lsp-encap-dscp-preserve
(config)#commit
```

mpls lsp-model uniform

Use this command to configure the MPLS LSP model as uniform.

Use the `no` parameter with this command to configure the MPLS LSP model as pipe or short-pipe.

Command Syntax

```
mpls lsp-model uniform
no mpls lsp-model uniform
```

Parameter

None

Default

By default, model configuration is pipe for XGS devices.

Qumran devices have the following default behavior:

- For L3VPN services, model is short-pipe by default and pipe model can be set by configuring policy-maps with match exp and set queue.
- For L2VPN services, short-pipe model is not supported and the default model is pipe.
- For L2VPN services with rewrite action pop, cos value will always be updated from qos profile irrespective of model.
- For L2VPN services without rewrite, uniform model command does not take effect until 'qos remark-cos' is configured on egress interface.

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls lsp-model uniform
(config)#exit

#configure terminal
(config)#no mpls lsp-model uniform
(config)#exit
```

mpls lsp-stitching

Use this command to stitch the LSP segment for an FEC created via a different label signaling protocol.

Use the `no` form of this command to disable this configuration.

Command Syntax

```
mpls lsp-stitching
no mpls lsp-stitching
```

Parameters

None

Default

By default, MPLS LSP stitching is disabled.

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 3.0.

Command Example

```
#configure terminal
(config)#mpls lsp-stitching
```

mpls map-route

Use this command to map a prefix to an FEC.

Use the `no` parameter with this command to disable this configuration.

Command Syntax

```
mpls map-route (A.B.C.D/M|A.B.C.D A.B.C.D) (A.B.C.D/M|A.B.C.D A.B.C.D)
no mpls map-route (A.B.C.D/M|A.B.C.D A.B.C.D)
```

Parameters

A.B.C.D	IPv4 prefix to map
A.B.C.D/M	IPv4 prefix to map, plus mask
A.B.C.D	Mask for IPv4 prefix to map
A.B.C.D/M	Mask for IPv4 prefix to map, plus mask.
A.B.C.D	IPv4 forwarding equivalence class for route to map
A.B.C.D	Mask for IPv4 forwarding equivalence class

Default

By default, `mpls map-route` is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

In the following examples 5.6.7.8/32 is the FEC for an LSP, and 1.2.3.4 is the prefix to be mapped.

```
#configure terminal
(config)#mpls map-route 1.2.3.4/32 5.6.7.8/32

#configure terminal
(config)#mpls map-route 1.2.3.4 255.255.255.255 5.6.7.8 255.255.255.255
```


mpls min-label-value

Use this command to configure minimum and maximum label value for a label space. Use module names (rsvp | ldp | bgp) to configure minimum and maximum label value for module in a label space, minimum and maximum label space value for a module should be within the range of label space being used. After setting minimum and maximum label value for a label space, make sure to bind the label space to an interface.

Use the `no` parameter with this command to use the default minimum and maximum label value for all the label pools.

Note: The system allows label-space range (maximum and minimum label values) changes for interface-specific label spaces only. The platform-wide label-space range cannot be modified.

Note: Only label-space 0 (global) is supported. Any label-space other than 0, is not supported.

Command Syntax

```
mpls (rsvp|ldp|bgp) min-label-value <16-1048575> max-label-value <16-1048575>
(label-space <0-60000>|)

no mpls min-label-value max-label-value (label-space <0-60000>|)

no mpls (rsvp|ldp|bgp) (label-space <0-60000>|)
```

Parameters

rsvp	Label range value for RSVP
ldp	Label range value for LDP
bgp	Label range value for BGP
min-label-value	Specify the minimum label value
<16-1048575>	Minimum size to be used for label pools or protocol range
max-label-value	Specify the maximum label value
<16-1048575>	Maximum size for all label pools
label-space	Label space for which the minimum value needs to be modified
<0-60000>	Range for label space

Default

By default, mpls min-label value is 16

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls min-label-value 50000 max-label-value 80000 label-space 0
```

mpls propagate-ttl

Use this command to enable TTL propagation. Enabling TTL propagation causes the TTL value in the IP header to be copied onto the TTL field in the shim header, at the LSP ingress.

Use the `no` parameter with this command to disable TTL propagation.

Command Syntax

```
mpls propagate-ttl
no mpls propagate-ttl
```

Parameters

None

Default

By default, TTL propagation is disabled.

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls propagate-ttl

#configure terminal
(config)#no mpls propagate-ttl
```

mpls traffic-eng srlg

Use this command to create a Shared Risk Link Group (SRLG). An SRLG uses secondary backup LSPs or Fast Reroute bypass/detour LSPs that minimize the probability of "fate sharing" with the path of the primary LSP.

Use the `no` form of this command to remove an SRLG.

Note: An interface can be part of multiple SRLG groups upto a maximum of 255 SRLG groups.

Any addition or deletion of SRLG value on an interface will not recalculate Primary/Backup. It is advised to configure SRLG values before bringing UP RSVP sessions or clear RSVP sessions after updating SRLG values.

Command Syntax:

```
mpls traffic-eng srlg <0-4294967295>
no mpls traffic-eng srlg <0-4294967295>
```

Parameters

<0-4294967295> Risk group number

Command Mode

Interface mode

Example

```
#configure terminal
(config)#int eth1
(config-if)#mpls traffic-eng srlg 1
```

ping mpls

Use this command to start sending MPLS request packets using various parameters as defined below. Ping packets can be configured for LDP, RSVP, L2 circuit, VPLS, L3 VPN, Segment Routing or generic FEC types.

Command Syntax

```
ping mpls (ldp A.B.C.D/M|rsvp (tunnel-name NAME|egress A.B.C.D)|l2-circuit <1-4294967295> |vpls <1-10000> peer A.B.C.D/M|l3vpn VRFNAME A.B.C.D/M |ipv4 A.B.C.D/M) ({reply-mode (1|2)|flags|destination A.B.C.D|source A.B.C.D|ttl <1-255>|timeout <1-500>|repeat <5-5000>|interval <2-20000>|force-explicit-null|detail})|)

ping mpls (l3vpn (VRFNAME A.B.C.D/M X:X::X:X/M source A.B.C.D destination A.B.C.D)) ({timeout <1-500>|ttl <1-255>|repeat <5-5000>|interval <2-20000>|detail})|)

ping mpls (6pe default X:X::X:X/M source A.B.C.D destination A.B.C.D)) ({timeout <1-500>|ttl <1-255>|repeat <5-5000>|interval <2-20000>|detail})|)

ping mpls (| protocol-origin (local | pcep) ) (sr-policy SR_POLICY_NAME (| candidate-path CANDIDATE_PATH_ID)) ({flags|source A.B.C.D | ttl <1-255> | timeout <1-500> | repeat <5-5000>|interval <2-20000> | force-explicit-null | detail})|)

ping mpls (ospf-sr | isis-sr) (ipv4 A.B.C.D/M) ({reply-mode (1|2|3)|flags | destination A.B.C.D|source A.B.C.D | ttl <1-255> | timeout <1-500> | repeat <5-5000>|interval <2-20000> | force-explicit-null | detail})|)
```

Parameters

ldp	FEC type is LDP
A.B.C.D/M	LDP prefix address
rsvp	FEC type is RSVP
tunnel-name	RSVP tunnel name
NAME	Tunnel name string
egress	RSVP tunnel egress
A.B.C.D	RSVP tunnel egress address
l2-circuit	FEC type is L2 circuit
<1-4294967295>	L2 circuit ID
vpls	FEC type is MPLS VPLS (L2-VPN)
<1-10000>	VPLS instance ID
peer	VPLS peer
A.B.C.D/M	VPLS peer address
l3vpn	FEC type is MPLS VPN (L3-VPN)
VRFNAME	VPN instance name
A.B.C.D./M	VPN prefix
X:X::X:X/M	VPNv6 prefix
6pe	FEC type (6PE)

default	VPN Instance Name (default)
X:X::X:X/M	6PE Prefix
ipv4	FEC type is generic; use for static/SNMP label switched paths
A.B.C.D/M	IPv4 prefix address
Protocol-origin	Protocol origin for SR policy
Local	local originated sr policy
Pcep	Pcep originated SR policy
SR policy	SR policy ping
SR_POLICY_NAME	Policy name
Candidate-path	Candidate path
CANDIDATE_PATH_ID	Candidate path id
reply-mode	Reply mode, one of
1	Do not reply
2	Reply via UDP/IP packet (default)
flags	Validate FEC stack
destination	Destination address
A.B.C.D	IPv4 address of the destination
source	Source address
A.B.C.D	IPv4 address of the source
ttl	Trace packet Time-to-live
<1-255>	Trace packet TTL value
repeat	Repeat sending of ping packets
<5-5000>	Number of pings to send
interval	Interval between ping packets, in milliseconds
<2-20000>	Interval value
timeout	Time to wait before rejecting the probe as a failure, in seconds
<1-500>	Timeout value
force-explicit-null	
	Force Explicit NULL label
detail	Print detailed output of the ping

Defaults

Default TTL value is 255.

Default timeout value is 60 seconds.

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3. The SR ping command was introduced in OcNOS version 4.1.

Example

```
#ping mpls ipv4 10.10.0.0/24 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

#ping mpls l2-circuit 3 reply-mode 2 flags destination 127.1.3.4 source 10.10.0.1
ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

#ping mpls l3vpn vrfa 10.10.0.0/24 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

#ping mpls ldp 10.10.0.0/24 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

#ping mpls rsvp egress 1.2.3.5 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

#ping mpls rsvp tunnel-name tun1 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

#ping mpls vpls 2 peer 10.10.0.0 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

# ping mpls sr-policy LSP3_R1_R4_R2 detail
# ping mpls ospf-sr ipv4 2.2.2.2/32 detail
# ping mpls isis-sr ipv4 2.2.2.2/32 detail
```

Codes:

```
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
```

Type 'Ctrl+C' to abort

```
! seq_num = 1 200.0.0.1 2.02 ms
! seq_num = 2 200.0.0.1 2.00 ms
! seq_num = 3 200.0.0.1 1.93 ms
! seq_num = 4 200.0.0.1 2.14 ms
! seq_num = 5 200.0.0.1 1.78 ms
```

```
Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 1.78/1.96/2.14
```

rewrite ingress

Use this command to configure a match VLAN action for a service template.

Use the `no` parameter with this command to remove a match VLAN action for a service template.

Command Syntax

```
rewrite ingress (((pop |translate <2-4094>)(|outgoing-tpid (dot1.ad |dot1.q))) |
(push <2-4094>))
no rewrite ingress (pop |push |translate)
```

Parameters

<code>pop</code>	POP the outer VLAN identifier from ACCESS->NETWORK and PUSH the match outer VID to NETWORK->ACCESS
<code>translate</code>	Translate the outer VLAN identifier to configured action VID for ACCESS->NETWORK and translate to the match outer VID for NETWORK->ACCESS
<code><2-4094></code>	Outer VLAN identifier
<code>outgoing-tpid</code>	Outgoing TPID, set the outer-tpid for the NETWORK->ACCESS
<code>dot1.ad</code>	Set TPID value as 0x88a8 for the traffic NETWORK->ACCESS
<code>dot1.q</code>	Set TPID value as 0x8100 for the traffic NETWORK->ACCESS
<code>push</code>	PUSH the outer VLAN identifier from ACCESS->NETWORK and POP the Outer VID from NETWORK->ACCESS
<code><2-4094></code>	Outer VLAN identifier

Command Mode

MPLS SVC mode

Applicability

This command was introduced in OcNOS version 1.3.3, and changed in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#service-template C2
(config-svc)#match double-tag outer-vlan 9 inner-vlan 8
(config-svc)#rewrite ingress translate 7 outgoing-tpid dot1.ad
(config-svc)#exit

(config)#service-template C2
(config-svc)#no rewrite ingress translate
(config-svc)#exit
```

secondary srlg-disjoint

Use this command to set how to avoid the SRLGs (Shared Risk Link Groups) of a protected primary.

A fast-reroute/secondary path for an LSP that is disjoint from the primary ensures that a single point of failure on a particular link does not bring down both the primary and secondary paths in the LSP.

Note: The SRLG option configured in RSVP-TRUNK mode (this command) takes higher preference than the option configured in RSVP router mode (see 'srlg-disjoint').

Use the `no` form of this command to not avoid the SRLGs of a protected interface.

Command Syntax

```
secondary srlg-disjoint (forced|preferred)
no secondary srlg-disjoint
```

Parameters

<code>forced</code>	The router does not create the secondary/backup tunnel unless it avoids SRLGs of the primary-path/protected-interface.
<code>preferred</code>	With two explicit paths, the first explicit path tries to avoid the SRLGs of the primary-path/protected interface. If that does not work, the secondary/backup tunnel uses the second path (which ignores SRLGs).

Command Mode

RSVP -TRUNK mode

Example

```
#configure terminal
(config)#rsvp-trunk t1
(config-rsvp)# secondary srlg-disjoint forced
```

secondary-priority srlg-disjoint

Use this command to set how to avoid the SRLGs (Shared Risk Link Groups) of a protected primary.

A fast-reroute/secondary path for an LSP that is disjoint from the primary ensures that a single point of failure on a particular link does not bring down both the primary and secondary paths in the LSP.

Note: The SRLG option configured in RSVP-TRUNK mode (this command) takes higher preference than the option configured in RSVP router mode (see the [srlg-disjoint](#) command).

Use the `no` form of this command to not avoid the SRLGs of a protected interface.

Command Syntax

```
secondary-priority <1-5> srlg-disjoint (forced|preferred)
no secondary-priority <1-5> srlg-disjoint
```

Parameters

<code>forced</code>	The router does not create the secondary/backup tunnel unless it avoids SRLGs of the primary-path/protected-interface.
<code>preferred</code>	With two explicit paths, the first explicit path tries to avoid the SRLGs of the primary-path/protected interface. If that does not work, the secondary/backup tunnel uses the second path (which ignores SRLGs).

Command Mode

RSVP -TRUNK mode

Example

```
#configure terminal
(config)#rsvp-trunk t1
(config-rsvp)# secondary-priority 1 srlg-disjoint forced
```

service-tpid

Use this command to configure service tpid for the MPLS layer-2 virtual circuit.

Use the no parameter with this command to delete service tpid from the MPLS layer-2 virtual circuit.

Command Syntax

```
service-tpid (dot1.q|dot1.ad|0x9100)
no service-tpid
```

Parameters

0x9100	Set tpid value as 0x9100
dot1.ad	Set tpid value as 0x88a8
dot1.q	Set tpid value as 0x8100

Default

By default, service-tpid is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#service-tpid dot1.ad
```

service-template

Use this command to configure a service template.

Use no form of this command to remove a service template.

Command Syntax

```
service-template NAME
no service-template NAME
```

Parameters

NAME	Name of the customer service template
------	---------------------------------------

Defaults

No default value is specified

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 1.3.3.

Examples

```
#configure terminal
(config)#service-template C1
(config-svc)#
```

show mpls

Use this command to display MPLS data.

Command Syntax

```
show mpls
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following subsection displays a variety of `show mpls` commands.

```
#show mpls
Minimum label configured: 16
Maximum label configured: 1048575
Per label-space information:
  Label-space 0 is using minimum label: 16 and maximum label: 1048575
  Label-space 2342 is using minimum label: 556 and maximum label: 1048575
Custom ingress TTL configured: none
Custom egress TTL configured: none
Log message detail: none
Admin group detail: none
Packets dropped IP:115167, dropped MPLS:0 sent to IP:490943, labeled:0,
switch
d:0

MPLS Differentiated Services Supported Classes data:
CLASS      DSCP_value
be         000000

MPLS Differentiated Services CLASS to EXP mapping data:
CLASS      DSCP_value      EXP_value
be         000000         0
#
```

[Table 1](#) explains the `show` command output fields.

Table 1: show mpls output field

Field	Description
Packets dropped IP	Displays the number of packets dropped over the internet protocol.
Dropped MPLS	Displays the number of packets dropped over the MPLS.

Table 1: show mpls output field

Field	Description
Sent to IP	Displays the number of packets transmitted to the internet protocol.
Labeled	Number of labeled packets in the interface. The MPLS-labeled packets are switched after a label lookup/switch instead of a lookup into the IP table. Labels of pop-and-forward mpls tunnel: P—Pop labels. D—Delegation labels.
Switch	Type of switching on the links needed for the MPLS.
Class	Creates a class map to be used for matching traffic to a specified class, and enters class-map configuration mode.
DSCP Value	The value of the DSCP and DSCP classifier is used for routing Layer 3 packets.
EXP value	Sets the value of the MPLS EXP field on all imposed label entries.

show admin-groups

Use this command to display all configured administrative groups.

Command Syntax

```
show admin-groups
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following sample shows the output of the `show admin-group` command.

```
#show admin-groups
Admin group detail:
Value of 0 associated with admin group 'a'
Value of 1 associated with admin group 'b'
Value of 2 associated with admin group 'c'
Value of 4 associated with admin group 'd'
#
```

[Table 2](#) explains the show command output fields.

Table 2: show admin-groups output field

Field	Description
Admin group detail	Display information about configured Multi Protocol Label Switching (MPLS) administrative groups.

show mpls bandwidth-class

Use this command to view bandwidth class parameters: bandwidth class name; allocated bandwidth; setup hold priority

Command Syntax

```
show mpls bandwidth-class
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
> show mpls bandwidth-class
Bandwidth-class: BW_1
Bandwidth: 6k          Setup-priority: 1  Class-type: 1
```

[Table 3](#) explains the show command output fields.

Table 3: show mpls bandwidth-class output field

Field	Description
Bandwidth-class	Bandwidth for each class type.
Bandwidth	Bandwidth configured for the active MPLS.
Setup-Priority	The setup priority is compared with other setup priorities for established sessions on the link to determine whether some of them should be preempted to accommodate the new session. Sessions with lower hold priorities are preempted.
Class-type	Bandwidth allocated for the specified class type.

show mpls counters ldp

Use this command to display traffic statistics for FTNs and ILMs configured by LDP.

Command Syntax

```
show mpls counters ldp ((ftn (|A.B.C.D/M)) | (ilm (|A.B.C.D/M)) |)
```

Parameter

ftn	FEC-to-NHLFE map counters
A.B.C.D/M	FEC prefix
ilm	Incoming label map counters
A.B.C.D/M	FEC prefix

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 1.3.2.

Note: For Qumran, counters are not available for transit nodes.

Examples

```
OcNOS#show mpls counter ldp
[FTN statistics]
```

```
+-----+-----+-----+-----+-----+-----+-----+-----+
|      FEC      | Pri | nhlfex | out-label | out-intf |  nexthop  | Tx packets | Tx bytes |
+-----+-----+-----+-----+-----+-----+-----+-----+
| 4.4.4.4/32    | 1   | 1      | 3         | xe3       | 10.10.1.2 | 62         | 4484    |
```

```
[ILM statistics]
```

```
+-----+-----+-----+-----+-----+-----+-----+-----+
|      FEC      | in-label | out-label | Rx packets | Rx bytes | Tx packets | Tx bytes |
+-----+-----+-----+-----+-----+-----+-----+-----+
```

[Table 4](#) explains the show command output fields.

Table 4: show mpls counters ldp output field

Field	Description
FTN statistics	Displays the statistics details of FTN.
ILM statistics	Displays the statistics details of ILM.
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
In-label	Displays the ingress (incoming interface) label for this segment.
Out-label	Displays the egress (outgoing interface) label for this segment.
Rx packets	Number of hello packets received from the neighbor.
Rx bytes	Size of hello packets received from the neighbor.

Table 4: show mpls counters ldp output field

Field	Description
Tx packets	Number of hello packets sent to the neighbor.
Tx bytes	Size of hello packets sent to the neighbor.

show mpls counters rsvp

Use this command to display traffic statistics for LSPs configured by RSVP.

Command Syntax

```
show mpls counters rsvp ((tunnel-name NAME) | (tunnel-id TUNNEL_ID) | (node-role
    (ingress | transit | egress)) |)
```

Parameter

NAME	RSVP tunnel name
TUNNEL_ID	RSVP tunnel identifier
ingress	LSP role is ingress
transit	LSP role is transit
egress	LSP role is egress

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 1.3.2.

Note: For Qumran, counters are not available for transit nodes.

Examples

```
#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 9.9.9.1 Egress 9.9.9.2
  lsp-name : t1-Primary                                [Ingress]
  lsp-ingress : 9.9.9.1                                lsp-id : 101
  Rx pkts : 0                                           Rx bytes : 0
  Tx pkts : 0                                           Tx bytes : 0

  lsp-name : t1-Secondary                                [Ingress]
  lsp-ingress : 9.9.9.1                                lsp-id : 102
  Rx pkts : 0                                           Rx bytes : 0
  Tx pkts : 0                                           Tx bytes : 0

Tunnel-id 5002 Extended Tunnel-ID 9.9.9.1 Egress 9.9.9.3
  lsp-name : t2-Primary                                [Ingress]
  lsp-ingress : 9.9.9.1                                lsp-id : 104
  Rx pkts : 0                                           Rx bytes : 0
  Tx pkts : 0                                           Tx bytes : 0

  lsp-name : t2-Detour                                [Ingress]
  lsp-ingress : 1.1.49.1                                lsp-id : 104
  Rx pkts : 0                                           Rx bytes : 0
  Tx pkts : 0                                           Tx bytes : 0
```

Table 5 explains the show command output fields.

Table 5: show mpls counters rsvp output field

Field	Description
Tunnel-id	Tunnel identifier (destination port) for the RSVP session.
Extended Tunnel-ID	Extended Tunnel identifier (destination port) for the RSVP session.
Egress	Egress router is the final MPLS device that removes the last label before packets leave the MPLS network.
Isp-name	Name of the SPRING-TE LSP.
Ingress	The router at the beginning of an LSP. This router encapsulates IP packets with an MPLS Layer 2 frame and forwards it to the next router in the path.
Isp-ingress	The router at the beginning of an LSP.
Isp-id	Specify the generic LSP identifier.
Rx packets	Number of hello packets received from the neighbor.
Rx bytes	Size of hello packets received from the neighbor.
Tx packets	Number of hello packets sent to the neighbor.
Tx bytes	Size of hello packets sent to the neighbor.

show mpls counters static

Use this command to display traffic statistics for statically configured FTNs and ILMs.

Command Syntax

```
show mpls counters static ((ftn (A.B.C.D/M|)) | (ilm (A.B.C.D/M|)) |)
```

Parameter

ftn	FEC-to-NHLFE map counters
A.B.C.D/M	FEC prefix
ilm	Incoming label map counters
A.B.C.D/M	FEC prefix

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 1.3.2.

Note: For Qumran, counters are not available for transit nodes.

Examples

```
#show mpls counters static
[ FTN statistics ]
```

```
+-----+-----+-----+-----+
|      FEC      | out-label | Tx packets | Tx bytes |
+-----+-----+-----+-----+
| 192.168.1.0/24 | 100       | 0          | 0        |
| 192.168.2.0/24 | 200       | 0          | 0        |
```

```
[ ILM statistics ]
```

```
+-----+-----+-----+-----+-----+-----+-----+
|      FEC      | in-label | out-label | Rx packets | Rx bytes | Tx packets | Tx bytes |
+-----+-----+-----+-----+-----+-----+-----+
| 0.0.0.0/0      | 201      | n/a      | 0          | 0        | n/a       | n/a      |
| 0.0.0.0/0      | 101      | n/a      | 0          | 0        | n/a       | n/a      |
| 192.168.3.0/24 | 301      | 302      | 0          | 0        | 0         | 0        |
| 192.168.4.0/24 | 401      | 402      | 0          | 0        | 0         | 0        |
```

```
#
```

[Table 6](#) explains the show command output fields.

Table 6: show mpls counters static output field

Field	Description
FTN statistics	Displays the statistics details of FTN.
ILM statistics	Displays the statistics details of ILM.
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
In-label	Displays the ingress (incoming interface) label for this segment.

Table 6: show mpls counters static output field

Field	Description
Out-label	Displays the egress (outgoing interface) label for this segment.
Rx packets	Number of hello packets received from the neighbor.
Rx bytes	Size of hello packets received from the neighbor.
Tx packets	Number of hello packets sent to the neighbor.
Tx bytes	Size of hello packets sent to the neighbor.

show mpls cross-connect-table

Use this command to display detailed information for all entries created in the MPLS cross-connect table.

Command Syntax

```
show mpls cross-connect-table
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output of the show mpls cross-connect-table

```
#show mpls cross-connect-table
Cross connect ix: 3, in intf: -, in label: 0, out-segment ix: 3
  Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 3, owner: RSVP, out intf: eth1, out label: 16
  Nexthop addr: 10.10.20.80, cross connect ix: 3, op code: Push

Cross connect ix: 6, in intf: -, in label: 0, out-segment ix: 6
  Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 6, owner: RSVP, out intf: eth1, out label: 17
  Nexthop addr: 10.10.20.80, cross connect ix: 6, op code: Push
#
```

[Table 7](#) explains the show command output fields.

Table 7: show mpls cross-connect-table output field

Field	Description
Cross connect ix	Displays the table index for the cross-connect.
In intf	Installed as a result of configuring an interface.
In label	Displays the ingress (incoming interface) label for this segment.
Out-segment ix	Displays the outbound segment index.
Owner	Displays the creator of this segment, typically a protocol such as BGP.
Persistent	Displays whether the tunnel is persistent – Yes or No.
Admin Status	Indicates whether the user can administratively disable a peer while still preserving its configuration. Up = Yes, Down = No.

Table 7: show mpls cross-connect-table output field

Field	Description
Oper Status	Displays the current status of the cross-connect segment – Up or Down
Nexthop addr	Displays the IP address of the next hop.
Op code	PUSH = Replace the top label with another and then push one or more additional labels onto the label stack SET = Set the next hop label.

show mpls cross-connect-table backup

Use this command to display detailed information for all entries created in the MPLS backup cross-connect table.

Command Syntax

```
show mpls cross-connect-table backup
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mod

Applicability

This command is newly introduced in OcNOS version 5.1.

Example

The following is a sample output of the show mpls cross-connect-table backup

```
#show mpls cross-connect-table backup
```

```
Backup Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 17
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 17, owner: LDP, Stale: NO, out intf: xe3, out label: 24324
Nexthop addr: 20.20.20.2 cross connect ix: 2, op code: Push
Primary xc-ix 2 out-segment ix 17

Backup Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 12
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe21, out label: 24320
Nexthop addr: 10.10.10.2 cross connect ix: 2, op code: Push
Primary xc-ix 2 out-segment ix 17
```

show mpls forwarding-table detail

Use this command to view forwarding table entries.

Command Syntax

```
show mpls forwarding-table ((A.B.C.D/M|X:X::X:X/M|) | count | detail |)
```

Parameters

A.B.C.D/M	FEC IPv4
X:X::X:X/M	FEC IPv6
count	Count of IPv4 FTNs.
detail	show detail

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3 and the detail option is applicable from OcNOS version 4.2.

Detail applicable form is modified to display backup information if present (only for LDP FTNs).

Example

If LFA flag is not enabled

```
#show mpls forwarding-table detail

FEC prefix: 41.41.41.41/32, FTN-ID: 5
  Owner: LDP, FTN type: Regular, State: Installed
  Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
  LSP-ID: N/A, LSP-type: Primary
  NHLFE-id: 7
  Out-Label: 3, Out-Intf: xe1, Nexthop: 50.50.50.1
  Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
  ELC: No
```

If LFA is enabled and backup not present:

```
FEC prefix: 41.41.41.41/32, FTN-ID: 5
  Owner: LDP, FTN type: Regular, State: Installed
  Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
  LSP-ID: N/A, LSP-type: Primary
  NHLFE-id: 7
Primary : Out-Label: 3, Out-Intf: xe1, Nexthop: 50.50.50.1
  Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
  ELC: No
```

If Backup is present:

```
#show mpls forwarding-table detail
FEC prefix: 10.10.10.0/24, FTN-ID: 2
  Owner: LDP, FTN type: Regular, State: Installed
  Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
  LSP-ID: N/A, LSP-type: Primary
  NHLFE-id: 4
  Primary : Out-Label: 3, Out-Intf: xe1, Nexthop: 50.50.50.1
  LFA Backup  : Out-Label: 3, Out-Intf: xe3, Nexthop: 20.20.20.1
  Primary : Out-Label: 3, Out-Intf: xe3, Nexthop: 20.20.20.1
  LFA Backup  : Out-Label: 3, Out-Intf: xe1, Nexthop: 50.50.50.1
  Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
  ELC: No
```

show mpls forwarding-table

Use this command to view forwarding table entries.

Command Syntax

```
show mpls forwarding-table ((A.B.C.D/M|X:X::X:X/M|) | count | detail |)
```

Parameters

A.B.C.D/M	FEC IPv4
X:X::X:X/M	FEC IPv6
count	Count of IPv4 FTNs.
detail	Show detail

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3 and the `detail` parameter added in OcNOS version 4.2. The output was extended to display backup Information as well.

Example

If Backup not present:

```
#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport
```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
L>	10.10.10.0/24	2	4	-	Yes	LSP_DEFAULT	3	xe1	No	50.50.50.1
				-	Yes	LSP_DEFAULT	3	xe3	No	20.20.20.1
L>	30.30.30.0/23	3	5	-	Yes	LSP_DEFAULT	3	xe1	No	50.50.50.1
L>	30.30.30.0/24	1	2	-	Yes	LSP_DEFAULT	3	xe6	No	40.40.40.2
L>	35.35.35.35/32	5	7	-	Yes	LSP_DEFAULT	3	xe6	No	40.40.40.2
L>	41.41.41.41/32	4	6	-	Yes	LSP_DEFAULT	3	xe1	No	50.50.50.1
L>	44.44.44.44/32	6	11	-	Yes	LSP_DEFAULT	3	xe3	No	20.20.20.1

#

If Backup is present:

```
#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport
```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
L>	10.10.10.0/24	2	4	-	Yes	LSP_DEFAULT	3	xe1	No	50.50.50.1
				-	No	LSP_DEFAULT	3	xe3	No	20.20.20.1
				-	Yes	LSP_DEFAULT	3	xe3	No	20.20.20.1
				-	No	LSP_DEFAULT	3	xe1	No	50.50.50.1
L>	30.30.30.0/23	3	5	-	Yes	LSP_DEFAULT	3	xe1	No	50.50.50.1
L>	30.30.30.0/24	1	2	-	Yes	LSP_DEFAULT	3	xe6	No	40.40.40.2

```

L> 35.35.35.35/32      5      7      -      Yes  LSP_DEFAULT  3      xe6      No  40.40.40.2
L> 41.41.41.41/32      4      6      -      Yes  LSP_DEFAULT  3      xe1      No  50.50.50.1
L> 44.44.44.44/32      6      11     -      Yes  LSP_DEFAULT  3      xe3      No  20.20.20.1
                                -      No  LSP_DEFAULT  24326  xe1      No  50.50.50.1
L> 1.1.1.1/32          2      4      -      Yes  LSP_DEFAULT  24320  xe12     No  20.1.1.1
                                11     -      No  LSP_DEFAULT  24320  xe5      No  30.1.1.1
                                11     -      Yes  LSP_DEFAULT  24320  xe5      No  30.1.1.1
                                3      -      No  LSP_DEFAULT  24320  xe12     No  20.1.1.1
L> 2.2.2.2/32          3      6      -      Yes  LSP_DEFAULT  3      xe12     No  20.1.1.1
                                15     -      No  LSP_DEFAULT  24324  xe5      No  1.1.1.1
                                (via 30.1.1.1 ,label 24320)
L> 3.3.3.3/32          1      2      -      Yes  LSP_DEFAULT  3      xe5      No  30.1.1.1
                                16     -      No  LSP_DEFAULT  24325  xe12     No  1.1.1.1
                                (via 20.1.1.1 ,label 24320)

```

show mpls ftn-table

Use this command to display FTN (FEC-To-NHLF) table information.

Command Syntax

```
show mpls ftn-table
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

If LFA is not present

```
#show mpls ftn-table
```

```
Primary FTN entry with FEC: 10.10.10.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 3
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 50.50.50.1          cross connect ix: 3, op code: Push
```

If Backup is present

```
#show mpls ftn-table
```

```
Primary FTN entry with FEC: 10.10.10.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 3
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 50.50.50.1          cross connect ix: 3, op code: Push
```

```
Backup Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 8
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: N/A, Stale: NO, out intf: xe3, out label: 3
Nexthop addr: 20.20.20.1          cross connect ix: 3, op code: Push
```

show mpls ilm-table

Use this command to view Incoming label mapping (ILM) table entries.

Command Syntax

```
show mpls ilm-table (count|)
```

Parameters

count Count of entries in ILM table.

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
      K - CLI ILM, T - MPLS-TP

Code  FEC                ILM-ID      In-Label  Out-Label  In-Intf  Out-
Intf   Nexthop              LSP-Type
> 63.63.63.63/32      151187      53121      3          N/A      xe6
6.6.6.63              LSP_DEFAULT
> 16.16.16.0/24      151186      53120      3          N/A      xe6
6.6.6.63              LSP_DEFAULT
K> N/A                151189      500        N/A        N/A      N/A
127.0.0.1              LSP_DEFAULT
> 65.65.65.65/32      151188      53122      3          N/A      xe1
1.1.1.65              LSP_DEFAULT

#show mpls ilm-table count
-----
Num ILMs           : 4          [UP: 4, INSTALL: 4]
  Swap Entries     : 3          [UP: 3, INSTALL: 3]
  Pop Entries      : 1          [UP: 1, INSTALL: 1]
-----
```

[Table 8](#) shows the status codes displayed at the start of a route entry.

Table 8: status code output field

Status Code	Field	Description
	Installed ILM	Number of ILM entry installed.
*	Selected ILM	ILM entry selected in the interface.
P	Stale ILM	Stale marked ILM due to on-going graceful restart of MPLS module.

Table 8: status code output field

Status Code	Field	Description
K	CLI ILM	Admin configured static ILM entry.
T	MPLS-TP	ILM entry installed by MPLS-TP.

Table 9 explains the show command output fields.

Table 9: show mpls ilm-table output field

Field	Description
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
ILM-ID	ILM identifier for the session.
LSP-Type	LSP type associated with each interface being protected.
Out-Label	Label received from downstream neighbor for route.
Out-Intf	Short name of the physical interface through which traffic goes to the protected link.
In label	Displays the ingress (incoming interface) label for this segment.
In intf	Installed as a result of configuring an interface.
Nexthop	Displays the IP address of the next hop.
Num ILMs	Number of ILMs in the session.
Swap Entries	Number of packets in the entry.
Pop Entries	Number of POP entries.

show mpls in-segment-table

Use this command to display detailed information about all entries in the Incoming Label Map (also known as in-segment) table.

Command Syntax

```
show mpls in-segment-table
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls in-segment-table
  Owner: RSVP, #of pops: 1, fec: 192.168.0.5/32
  RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
LSP Type: ELSP_CONFIG
Class_Exp mapping:
CLASS_  DSCP_value      EXP_value
be      000000          0
  Cross connect ix: 1, in intf: eth0 in label: 52480 out-segment ix: 1
  Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 1, owner: RSVP, out intf: eth1, out label: 52480
  Nexthop addr: 20.30.0.3      cross connect ix: 1, op code: Swap
  Cross connect ix: 1, in intf: eth0 in label: 52480 out-segment ix: 2
  Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 2, owner: RSVP, out intf: eth2, out label: 52481
  Nexthop addr: 30.30.0.3      cross connect ix: 1, op code: Swap
#
```

Table 10 explains the show command output fields.

Table 10: show mpls in-segment-table output field

Field	Description
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
RX bytes	Size of hello packets received from the neighbor.
Pkts	Number packet in the interface.
TX bytes	Size of the packets that transmitted to the neighbor.
Swapped pkts	Number of swapped packets in session.

Table 10: show mpls in-segment-table output field

Field	Description
Popped pkts	Number of popped packets in the interface.
LSP-Type	LSP type associated with each interface being protected.
CLASS	Creates a class map to be used for matching traffic to a specified class, and enters class-map configuration mode.
DSCP value	The value of the DSCP and DSCP classifier is used for routing Layer 3 packets.
EXP value	Sets the value of the MPLS EXP field on all imposed label entries.
Cross-connect ix	Displays the table index for the cross-connect.
Out-Label	Label received from downstream neighbor for route.
Out-Intf	Short name of the physical interface through which traffic goes to the protected link.
In label	Displays the ingress (incoming interface) label for this segment.
In intf	Installed as a result of configuring an interface.
Nexthop	Displays the IP address of the next hop.
Out-segment ix	Displays the outbound segment index.
Persistent	Displays whether the tunnel is persistent – Yes or No.
Admin Status	Indicates whether the user can administratively disable a peer while still preserving its configuration. Up = Yes, Down = No.
Oper Status	Displays the current status of the cross-connect segment – Up or Down.
Op code	PUSH = Replace the top label with another and then push one or more additional labels onto the label stack. SET = Set the next hop label.

show mpls l2-circuit

Use this command to view MPLS-TP L2 circuit parameters.

Command Syntax

```
show mpls l2-circuit (detail|)
show mpls l2-circuit NAME (detail|)
```

Parameters

detail	Show detailed information
NAME	The name of the virtual circuit

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls l2-circuit detail
MPLS Layer-2 Virtual Circuit: vc1, id: 1 PW-INDEX: 1 service-tpid: 8100

Endpoint: 1.1.1.1
Control Word: 0
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe41
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : C1
Match criteria : 10-14, 16-20
```

[Table 11](#) explains the show command output fields.

Table 11: show mpls l2-circuit output field

Field	Description
MPLS Layer-2 Virtual Circuit	The MPLS virtual circuit on the egress PE router or switch and the specified neighbor, testing the integrity of the Layer 2 circuit between the ingress and egress PE routers or switches.
Endpoint	Endpoint address.
Control Word	Number of control words.
MPLS Layer-2 Virtual Circuit Group	The MPLS virtual circuit group on the egress PE router or switch and the specified neighbor, testing the integrity of the Layer 2 circuit between the ingress and egress PE routers or switches.

Table 11: show mpls l2-circuit output field

Field	Description
Bound to interface	A bound service is the server in a client-server interface.
Virtual Circuit Type	Type of virtual circuit in the interface.
Service-template	Service Templates provides a powerful mechanism to configure advanced service-related options.
Match criteria	The match criteria under which redistribution is allowed for the current route-map.

show mpls l2-circuit statistics

Use this command to display MPLS traffic statistics for L2 circuit.

Command Syntax

```
show mpls l2-circuit NAME statistics (access-port|network-port|)
```

Parameters

NAME	Name of L2 circuit
access-port	Displays the access port statistics
network-port	Displays the network port statistics

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls l2-circuit t1 statistics
MPLS Layer-2 Virtual Circuit: t1, id 100          # Virtual circuit name and ID
Access port statistics:
  RX: Input packets : 1000
      Input bytes   : 120000
  TX: Output packets: 0
      Output bytes  : 0
Network port statistics:
  RX: Input packets : 0
      Input bytes   : 0
  TX: Output packets: 1000
      Output bytes  : 120000
```

[Table 12](#) explains the show command output fields.

Table 12: show mpls l2-circuit statistics output field

Field	Description
MPLS Layer-2 Virtual Circuit	The MPLS virtual circuit on the egress PE router or switch and the specified neighbor, testing the integrity of the Layer 2 circuit between the ingress and egress PE routers or switches.
Virtual circuit name and ID	The MPLS virtual circuit identifier on the egress PE router or switch and the specified neighbor, testing the integrity of the Layer 2 circuit between the ingress and egress PE routers or switches.
Access port statistics	Traffic statistics on Access port of VC/VPLS.
Network port statistics	Traffic statistics on Provider port of VC/VPLS.
RX	Number of received packets.

Table 12: show mpls l2-circuit statistics output field

Field	Description
Input packets	Number of hello packets received from the neighbor.
Input bytes	Size of hello packets received from the neighbor.
TX	Number of packets transmitted.
Output packets	Number of hello packets sent to the neighbor.
Output bytes	Size of hello packets sent to the neighbor.

show mpls mapped-routes

Use this command to view MPLS mapped routes.

Use the `no` parameter with this command to reset this configuration.

Command Syntax

```
show mpls mapped-routes
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls mapped-routes
```

Mapped-route	IPv4 FEC	MPLS-TP Tunnel
14.1.2.3/32	N/A	NH4

[Table 13](#) explains the show command output fields.

Table 13: show mpls mapped-routes output field

Field	Description
Mapped-route	Map the route of the interface.
IPv4	IPv4 address of the neighbor interface.
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
MPLS-TP Tunnel	MPLS-TP tunnel can be provisioned between two arbitrary nodes in an MPLS-TP enabled network.

show mpls out-segment-table

Use this command to display detailed information of out-segment entries (also known as NHLFE) table.

Command Syntax

```
show mpls out-segment-table
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls out-segment-table
Out-segment with ix: 1, owner: RSVP, out intf: eth1, out label: 52480
  Nexthop addr: 20.30.0.3          cross connect ix: 1, op code: Swap
  TX bytes:0, pkts:0, error pkts:0, discard pkts:0

Out-segment with ix: 2, owner: RSVP, out intf: eth2, out label: 52481
  Nexthop addr: 30.30.0.3          cross connect ix: 1, op code: Swap
  TX bytes:0, pkts:0, error pkts:0, discard pkts:0Zx
```

[Table 14](#) explains the show command output fields.

Table 14: show mpls out-segment-table output field

Field	Description
Out-segment ix	Displays the outbound segment index.
Out-Label	Label received from downstream neighbor for route.
Out-Intf	Short name of the physical interface through which traffic goes to the protected link.
Nexthop addr	Displays the IP address of the next hop.
Cross-connect ix	Displays the table index for the cross-connect.
Op code	PUSH = Replace the top label with another and then push one or more additional labels onto the label stack. SET = Set the next hop label.
Pkts	Number packet in the interface.
TX bytes	Size of the packets that transmitted to the neighbor.

Table 14: show mpls out-segment-table output field

Field	Description
Error pkts	Number of error packets.
Discard pkts	Number of packets discarded in the interface.

show mpls owner-rib-table

This command is modified to display backup information when LDP_LFA is enabled.

Command Syntax:

```
show mpls owner-rib-table
```

Parameters

None

Example

If LFA flag is disabled.

```
#show mpls owner-rib-table count
=====
RIB INFO  Type : LDP
Session IP Address: 41.41.41.41  Label Space: 0
Ftn Count 4, ILM Count 2 Dep ILM 2 VC 0
=====
```

If LFA is enabled and Backup entries is not present.

```
#show mpls owner-rib-table count
=====
RIB INFO  Type : LDP
Session IP Address: 41.41.41.41  Label Space: 0
Ftn Count 4, ILM Count 2 Dep ILM 2 VC 0
Backup Info
Ftn Count 0, ILM Count 0 Dep ILM 0
=====
```

If Backup entries are present.

```
#show mpls owner-rib-table count
=====
RIB INFO  Type : LDP
Session IP Address: 41.41.41.41  Label Space: 0
Ftn Count 4, ILM Count 2 Dep ILM 2 VC 0
Backup Info
Ftn Count 4, ILM Count 0 Dep ILM 0
=====
=====
RIB INFO  Type : LDP
Session IP Address: 17.17.17.17  Label Space: 0
Ftn Count 4, ILM Count 2 Dep ILM 2 VC 0
Backup Info
Ftn Count 4, ILM Count 0 Dep ILM 0
```

show mpls qos-resource

Use this command to display detailed QoS resource information.

Command Syntax

```
show mpls qos-resource IFNAME
```

Parameters

IFNAME	Display the interface name for a QoS resource
--------	---

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls qos-resource eth1
<*****>
      QOS RESERVED TABLE
<*****>
HOLD PRIORITY : 0

HOLD PRIORITY : 1

HOLD PRIORITY : 2

HOLD PRIORITY : 3

HOLD PRIORITY : 4

HOLD PRIORITY : 5

HOLD PRIORITY : 6

HOLD PRIORITY : 7
<*****>
      QOS AWAITING TABLE (static resources)
<*****>
HOLD PRIORITY : 0

HOLD PRIORITY : 1

HOLD PRIORITY : 2

HOLD PRIORITY : 3

HOLD PRIORITY : 4

HOLD PRIORITY : 5

HOLD PRIORITY : 6
```

```
HOLD PRIORITY : 7
TSUP-173>
```

Table 15 explains the show command output fields.

Table 15: show mpls qos-resource output fields

Field	Description
QOS RESERVED TABLE	FTM/ILM entries for which QOS is reserved.
HOLD PRIORITY	Determines the degree to which an LSP holds onto its session reservation after the LSP has been set up successfully
QOS AWAITING TABLE (static resources)	FTN/ILM entries for which QOS reservation is pending.

show mpls vc-table

Use this command view configured virtual circuit (VC) components

Command Syntax

```
show mpls vc-table
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#show mpls vc-table
```

```
VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label Tunnel-Label
NextHop Status
500    N/A      N/A      eth2      eth1      544      57
N/A    Active
#
```

[Table 16](#) explains the show command output fields.

Table 16: show mpls vc-table output fields

Field	Description
VC-ID	The virtual circuit ID for the Provider Edge (PE) MPLS.
Vlan-ID	Virtual LAN (VLAN) ID number.
Inner-Vlan-ID	Inner Virtual LAN (VLAN) ID number.
Access-Intf	The Interface Access page provides a method with which to control access to specific areas of the interface.
Network-Intf	A networking interface allows a computer or mobile device to connect to a local area network (LAN) using Ethernet as the transmission mechanism.
Out Label	Label received from downstream neighbor for route.
Tunnel-Label	Used to provide reachability between PE devices.
NextHop Status	Displays the network status of the next hop.

show mpls vrf

Use this command to display detailed information of all the configured VRF entries. Specify the name of the VRF to display information about a specific VRF entry.

Command Syntax

```
show mpls vrf-table
show mpls vrf-table VRFNAME (count|)
```

Parameters

VRFNAME	Display the MPLS VRF table by its configured name
count	Display the MPLS VRF FTN's count

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#show mpls vrf new_vrf count
-----
Num VRF-FTNs           : 1           [UP: 1, INSTALLED: 1]
-----
Num VRF-FTNs           : 0           [UP: 0]
-----
```

[Table 17](#) explains the show command output fields.

Table 17: show vrf-table output fields

Field	Description
Num VRF-FTNs	Number of FEC-to-NHLFE map counters in VRF protocol.
Num VRF-FTNs	Number of VRF FEC-to-NHLFE map counters in protocol.

show mpls vrf-forwarding-table vrf

This CLI can be used to display a tabular output of the VRF forwarding entries received from the remote PE via MPBGP.

Command Syntax

```
show mpls vrf-forwarding-table vrf <VRFNAME>
```

Parameters

VRFNAME Display the MPLS VRF table by its configured name

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.1.

Examples

```
#show mpls vrf-forwarding-table vrf BEVrf
Owner      FEC                      FTN-ID  Oper-Status  Out-Label  Tunnel-id  NHLFE-id  Out-Intf  Nexthop
BGP        10.143.73.1/32                1       Up           24320      0          19        xe25      10.143.73.1
BGP        10.143.73.10/32               6       Up           25600      0          30        xe4       10.143.73.10
BGP        10.143.169.26/31             2       Up           24320      0          19        xe25      10.143.73.1
BGP        10.143.170.26/31             3       Up           24324      0          28        xe4       10.143.73.6
```

[Table 18](#) explains the show command output fields.

Table 18: show mpls vrf-forwarding-table vrf output fields

Field	Description
Owner	Displays the creator of this entry, typically a protocol such as BGP.
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
FTN-ID	FEC-to-NHLFE identification.
Oper-Status	Displays the current status of the entry – Up or Down. It will be “UP” if the vrf entry is installed in the forwarder and it will be in “DOWN” state if the vrf entry is not installed in the forwarder.
Out-Label	Displays the egress label for this FTN.
Tunnel-id	Tunnel identification to which packets of this FTN are going.
NHLFE-id	Next Hop Label Forwarding Entry identification (also known as out-segment entry identification).
Out-Intf	Name of the physical interface through which traffic goes.
Nexthop	Displays the IP address of the next hop.

show running-config interface mpls

Use this command to show the running system status and configuration for an MPLS interface.

Command Syntax

```
show running-config interface IFNAME mpls
```

Parameters

IFNAME	Display information for this interface name
--------	---

Command Mode

Privileged Exec mode and Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show running-config interface eth1 mpls  
  
#
```

show running-config mpls

Use this command to show any Multi-Protocol Label Switching (MPLS) related running configuration.

Command Syntax

```
show running-config mpls
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
>enable
#show running-config mpls
!
mpls propagate-ttl
!
!
!
#
```

show running-config service-template

Use this command to show service-template related running configuration.

Command Syntax

```
show running-config service-template
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#sho running-config service-template
!
service-template s2
  match outer-vlan 200
!
service-template s1
  match outer-vlan 100
!
service-template s3
  match outer-vlan 300
!
service-template s4
  match outer-vlan 400
!
```

show running-config vc

Use this command to show any Virtual Private Wire Service (VPWS) related running configuration.

Command Syntax

```
show running-config vc
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#show running-config vc
!
mpls l2-circuit vc1 1 2.2.2.2
!
mpls l2-circuit vc2 3 2.2.2.2
  tunnel-select-policy p1
!
!
interface xe2
  mpls-l2-circuit vc1 service-template s1 primary
  mpls-l2-circuit vc2 service-template s3 primary
!
```

show running-config vpls

Use this command to show any Virtual Private LAN Service (VPLS) related running configuration.

Command Syntax

```
show running-config vpls
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#show running-config vpls
!
mpls vpls vpls1 2
  signaling ldp
  vpls-type vlan
  vpls-peer 2.2.2.2
  exit-signaling
  exit-vpls
!
mpls vpls vpls2 4
  signaling ldp
  vpls-type vlan
  vpls-peer 2.2.2.2 tunnel-select-policy p1
  exit-signaling
  exit-vpls
!
!
interface xe2
  mpls-vpls vpls1 service-template s2
  mpls-vpls vpls2 service-template s4
  split-horizon group access1
!
```

show service-template

Use this command to display information of all or particular service templates.

Command Syntax

```
show service-template (detail|)
show service-template NAME
```

Parameters

detail	Show detailed information
NAME	Name of customer service template

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 1.3.3.

Examples

```
#show service-template detail
Service-template : C2
Services mapped : -
Match criteria : 9/8

Service-template : C1
Services mapped : -
Match criteria : 100

Service-template : C3
Services mapped : -
Match criteria : 2-5

#show service-template C1
Service-template : C1
Services mapped : -
Match criteria : 100
```

[Table 19](#) explains the show command output fields.

Table 19: show service template output fields

Field	Description
Service-template	Creates a service template and enters service template configuration mode.
Services mapped	Used to match the type of services.
Match criteria	Used to approve the identification result or dismiss it.

show vccv statistics

Use this command to display VCCV messages received prior to advertising capability.

Command Syntax

```
show vccv statistics
```

Parameters

None

Command Mode

Privileged mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following is the sample output for `show vccv statistics` command.

```
#show vccv statistics
CC Mismatch Discards - 10
```

[Table 20](#) explains the show command output fields.

Table 20: show vccv statistics output fields

Field	Description
CC Mismatch Discards	Number of CC mismatch packets received from neighbor discarded.

srlg-disjoint

Use this command to set how to avoid the SRLGs (Shared Risk Link Groups) of a protected primary.

A fast-reroute/secondary path for an LSP that is disjoint from the primary ensures that a single point of failure on a particular link does not bring down both the primary and secondary paths in the LSP.

Note: The SRLG option configured in RSVP-TRUNK mode (see the [secondary-priority srlg-disjoint](#) command) takes higher preference than the option configured in RSVP router mode (this command).

Use the `no` form of this command to not avoid the SRLGs of a protected interface.

Command Syntax

```
srlg-disjoint (forced|preferred)
no srlg-disjoint
```

Parameters

<code>forced</code>	The router does not create the secondary/backup tunnel unless it avoids SRLGs of the primary-path/protected-interface.
<code>preferred</code>	With two explicit paths, the first explicit path tries to avoid the SRLGs of the primary-path/protected interface. If that does not work, the secondary/backup tunnel uses the second path (which ignores SRLGs).

Command Mode

Router RSVP mode

Example

```
#configure terminal
(config)#router rsvp
(config-rsvp)# srlg-disjoint forced
```

trace mpls

Use this command to trace the route traversed by a specified echo request packet in an MPLS protocol. Trace requests can be configured for LDP, RSVP, L2 VC, VPLS, Segment Routing and L3 VPN label switched paths.

```
trace mpls (6pe default X:X::X:X/M|ldp A.B.C.D/M|rsvp (tunnel-name NAME|egress
A.B.C.D)|l3vpn VRFNAME A.B.C.D/M|ipv4 A.B.C.D/M) ({reply-mode
(2)|flags|destination A.B.C.D|source A.B.C.D|timeout <1-500>|force-explicit-
null|detail}||)

trace mpls (ospf-sr | isis-sr ) (ipv4 A.B.C.D/M | sr-policy SR_POLICY_NAME
candidate-path CANDIDATE_PATH_ID) ({reply-mode (2|3)|flags | destination A.B.C.D
|source A.B.C.D | ttl <1-255> | timeout <1-500> | detail}||)
```

Parameters

6pe	FEC type is 6pe
default	VPN Instance Name (default)
X:X::X:X/M	6pe prefix address
ldp	FEC type is LDP
A.B.C.D/M	LDP prefix address
rsvp	FEC type is RSVP
tunnel-name	RSVP tunnel name
NAME	Tunnel name string
egress	RSVP tunnel egress
A.B.C.D	RSVP tunnel egress address
l3vpn	FEC type is MPLS VPN (L3-VPN)
VRFNAME	VPN instance name
A.B.C.D./M	VPN prefix
ipv4	FEC type generic; use for static/SNMP label switched paths
A.B.C.D/M	IPv4 prefix address
X:X::X:X/M	VPNv6 prefix
Ospf-sr	SR Protocol OSPF
Isis-sr	SR protocol ISIS
Ipv4	IPV4 FEC
A.B.C.D/M	Prefix with mask
Sr-policy	SR policy trace
SR_POLICY_NAME	SR policy name
Candidate-path	candidate path in sr policy
CANDIDATE_PATH_ID	candidate path id
reply-mode	Reply mode, one of
2	Reply via UDP/IP packet (default)
flags	Validate FEC stack

destination	Destination address
A.B.C.D	IPv4 address of the destination
source	Source address
A.B.C.D	IPv4 address of the source
timeout	Time to wait before rejecting the probe as a failure, in seconds
<1-500>	Timeout value
force-explicit-null	Force Explicit NULL label
detail	Print detailed output of the trace probe

Defaults

Default timeout value is 60 seconds.

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3. The SR trace command was introduced in OcNOS version 4.1.

Examples

```
#trace mpls ipv4 10.10.0.0/24 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 timeout 65 detail force-explicit-null

#trace mpls l3vpn vrfa 10.10.0.0/24 reply-mode 2 flags destination 127.1.2.3
source 10.10.0.1 timeout 65 detail force-explicit-null

#trace mpls ldp 10.10.0.0/24 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 timeout 65 detail force-explicit-null

#trace mpls rsvp egress 1.2.3.5 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 timeout 65 detail force-explicit-null

#trace mpls rsvp tunnel-name tun1 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 timeout 65 detail force-explicit-null

# trace mpls isis-sr ipv4 2.2.2.2/32 detail
# trace mpls ospf-sr ipv4 2.2.2.2/32 detail

# trace mpls isis-sr sr-policy aaa candidate-path 1
# trace mpls ospf-sr sr-policy ABC candidate-path 1
```

tunnel-id

Use this command to configure tunnel identifier for the MPLS transport tunnel to be used for the MPLS layer-2 virtual circuit.

Use the no parameter with this command to delete tunnel identifier from the MPLS layer-2 virtual circuit.

Command Syntax:

```
tunnel-id <1-5000>
no tunnel-id
```

Parameters

<1-5000>	Identifying value for Tunnel-id
----------	---------------------------------

Default

By default, tunnel-id is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#tunnel-id 22
```

tunnel-name

Use this command to configure tunnel name for the MPLS transport tunnel to be used for the MPLS layer-2 virtual circuit.

Use the no parameter with this command to delete tunnel name from the MPLS layer-2 virtual circuit.

Command Syntax:

```
tunnel-name NAME
no tunnel-name
```

Parameters

NAME	Identifying name for MPLS Tunnel
------	----------------------------------

Default

By default, tunnel-name is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#tunnel-name pe1-to-pe2
```

tunnel-select-policy

Use this command to configure tunnel selection policy name for the MPLS transport tunnel to be used for the MPLS layer-2 virtual circuit.

Use the no parameter with this command to delete tunnel selection policy name from the MPLS layer-2 virtual circuit.

Command Syntax

```
tunnel-select-policy POLICYNAME
no tunnel-select-policy
```

Parameters

POLICYNAME	Selection policy name for MPLS Tunnel
------------	---------------------------------------

Default

By default, tunnel-select-policy is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#tunnel-select-policy policy1
```

vccv cc-type

Use this command to configure the VCCV control channel for MPLS layer-2 virtual circuit.

Use the no parameter with this command to disable control channel from MPLS layer-2 virtual circuit.

Command Syntax

```
vccv cc-type (type-1|type-2|type-3)
no vccv cc-type (type-1|type-2|type-3)
```

Parameters

type-1	CC Type 1 - PWE3 Control Word with 0001b as first nibble
type-2	CC Type 2 - MPLS Router Alert Label
type-3	CC Type 3 - MPLS PW Label with TTL == 1

Default

By default, vccv is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)# vccv cc-type type-2
```

vccv cv-type

Use this command to configure the VCCV control verification for MPLS layer-2 virtual circuit.

Use the no parameter with this command to disable control verification from MPLS layer-2 virtual circuit.

Command Syntax:

```
vccv cv-type (type-1|type-2|type-3|type-4)
no vccv cv-type (type-1|type-2|type-3|type-4)
```

Parameters

type-1	BFD IP/UDP-encapsulated for PW Fault Detection only
type-2	BFD IP/UDP-encapsulated for PW Fault Detection and AC/PW Fault Status Signalling
type-3	BFD PW-ACH-encapsulated for PW Fault Detection only
type-4	BFD PW-ACH-encapsulated for PW Fault Detection and AC/PW Fault Status Signalling

Default

By default, vccv is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)# vccv cv-type type-1
```

CHAPTER 2 Differentiated Services Commands

This chapter describes the RSVP Differentiated Services (DiffServ) commands.

- `map-route A.B.C.D`
- `override-diffserv`
- `primary class-to-exp-bit`
- `primary elsp-signaled`
- `primary llsp`
- `secondary map class`
- `secondary elsp-signaled`
- `secondary llsp`
- `show rsvp diffserv-info`

map-route A.B.C.D

Use this command to map a IPv4 prefix route onto a trunk. This route is to be used for packets that are mapped to a specific RSVP trunk.

Use the `no` parameter with this command for unmapping routes from specified trunks.

Note: Do not configure the local address as a map route, as explicit validation is not done. The wrong configuration may impact traffic.

Command Syntax

```
map-route A.B.C.D A.B.C.D
map-route A.B.C.D A.B.C.D CLASS
map-route A.B.C.D/M
map-route A.B.C.D/M CLASS
no map-route A.B.C.D A.B.C.D
no map-route A.B.C.D A.B.C.D CLASS
no map-route A.B.C.D/M
no map-route A.B.C.D/M CLASS
```

Parameters

A.B.C.D	Specify the IPV4 address to be mapped.
A.B.C.D	Specify a mask to be applied to the address being mapped.
A.B.C.D/M	Specify the IPV4 address to be mapped, with mask.
CLASS	Specify the DiffServ Class Name (for example, <code>be</code> , <code>ef</code> etc.) used for selecting incoming IP packets to be mapped to a specified RSVP trunk.

Default

By default, map route A.B.C.D is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#map-route 1.1.2.2/24 be
```

override-diffserv

Use this command to enable the Differentiated Services (Diff-Serv) override configuration.

If a Path message is received without a Diff-Serv object by a Diff-Serv enabled node, it can be interpreted either as a request for an E-LSP (EXP-Inferred-PSC LSP) or as a request for Non-Diff-Serv LSP. This command supports the override option and when configured, the LSR interprets a path message without a Diff-Serv object as a request for Non-Diff-Serv LSP.

Use the `no` parameter with this command disable this feature.

Command Syntax

```
override-diffserv
no override-diffserv
```

Parameters

None

Default

By default, override diffserv is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router rsvp
(config-router)#override-diffserv
```


primary class-to-exp-bit

Use this command to configure a primary PHB-EXP (Per-Hop Behavior-Experimental) mapping to be used by an E-LSP (EXP-Inferred-PSC LSP). This mapping is different from the node level PHB-EXP mapping.

Use the `no` parameter with this command to remove a PHB-EXP mapping configuration from current E-LSP PHB-EXP mapping.

Command Syntax

```
primary class-to-exp-bit CLASS <0-7>
no primary class-to-exp-bit CLASS <0-7>
```

Parameters

CLASS	Specify the DiffServ Class Name (for example, be, ef etc.) used for selecting incoming IP packets to be mapped to a specified RSVP trunk.
<0-7>	Exp bit which is to be mapped to this PHB.

Default

By default, primary map class is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary class-to-exp-bit af12 3

(config)#rsvp-trunk T1
(config-trunk)#no primary class-to-exp-bit af12 3
```

primary elsp-signaled

Use this command to configure a primary Diff-Serv (Differentiated Services) explicitly signaled E-LSP (EXP-Inferred-PSC LSP) interface.

The classes 1 to 7 are optional parameters that can be selected from node level PHB-EXP (Per-Hop Behavior) mapping as PHBs, which will then be used for an E-LSP. If you do not specify a class with this command, all classes will be selected for the E-LSP.

Use the no parameter with this command to remove the configuration.

Command Syntax

```
primary elsp-signaled
primary elsp-signaled CLASS1
primary elsp-signaled CLASS1 CLASS2
primary elsp-signaled CLASS1 CLASS2 CLASS3
primary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4
primary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5
primary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5 CLASS6
primary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5 CLASS6 CLASS7
no primary elsp-signaled
```

Parameter

CLASS<0-7> Diffserv class alias. e.g.: be, ef, af11, etc.

Default

By default, primary elsp signaled is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary elsp-signaled cs2 cs5 cs6

(config)#rsvp-trunk T1
(config-trunk)#no primary elsp-signaled
```

primary llsp

Use this command to configure a primary Differentiated Services Label-Only-Inferred-PSC (Diff-Serv L-LSP) interface, which will use Diff-Serv Class as its PHB Scheduling Class (PSC).

Use the no parameter with this command to remove the Diff-Serv L-LSP configuration.

Command Syntax

```
primary llsp CLASS
no primary llsp
```

Parameters

CLASS<0-7> Diffserv class alias. e.g: be, ef, af11, etc.

Default

By default, primary llsp is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

This command is not available on QUMRAN devices.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary llsp cs4

(config)#rsvp-trunk T1
(config-trunk)#no primary llsp
```

secondary map class

Use this command to configure a secondary PHB-EXP (Per-Hop Behavior-Experimental) mapping to be used by an E-LSP (EXP-Inferred-PSC LSP). This mapping is different from the node level PHB-EXP mapping.

Use the no parameter with this command to remove a PHB-EXP mapping configuration from current E-LSP PHB-EXP mapping.

Command Syntax

```
secondary map class-to-exp-bit CLASS <0-7>
no secondary map class-to-exp-bit CLASS <0-7>
```

Parameters

CLASS	Diff-Serv class (queue) mapped to the particular PHB. Diffserv class alias e.g: be, ef, af11, etc.
<0-7>	Exp bit that is to be mapped to this PHB.

Default

By default, secondary map class is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary class-to-exp-bit cs4 3

(config)#rsvp-trunk T1
(config-trunk)#no secondary class-to-exp-bit cs4 3
```

secondary elsp-signaled

Use this command to configure a secondary Diff-Serv (Differentiated Services) explicitly signaled E-LSP (EXP-Inferred-PSC LSP) interface. The classes 1 to 7 are optional parameters can be selected from the node level PHB-EXP (Per-Hop Behavior) mapping as PHBs. They will then be used for an E-LSP. If you do not specify a class with this command, all classes will be selected for the E-LSP.

Use the no parameter with this command to remove the configuration.

Command Syntax

```
secondary elsp-signaled
secondary elsp-signaled CLASS1
secondary elsp-signaled CLASS1 CLASS2
secondary elsp-signaled CLASS1 CLASS2 CLASS3
secondary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4
secondary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5
secondary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5 CLASS6
secondary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5 CLASS6 CLASS7
no secondary elsp-signaled
```

Parameters

CLASS<0-7> Diffserv class alias. e.g: be, ef, af11, etc.

Default

By default, secondary elsp signaled is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary elsp-signaled class cs3 cs6 cs2 cs5

(config)#rsvp-trunk T1
(config-trunk)#no secondary elsp-signaled
```

secondary llsp

Use this command to configure a secondary Differentiated Services Label-Only-Inferred-PSC (Diff-Serv L-LSP) interface, which will use Diff-Serv Class as its PHB Scheduling Class (PSC).

Use the no parameter with this command to remove the Diff-Serv L-LSP configuration.

Command Syntax

```
secondary llsp CLASS
no secondary llsp
```

Parameters

CLASS<0-7> Diffserv class alias. e.g: be, ef, af11, etc.

Default

By default, secondary llsp is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

This command is not available on QUMRAN devices.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary llsp class cs5

(config)#rsvp-trunk T1
(config-trunk)#no secondary llsp
```

show rsvp diffserv-info

Use this command to display node level Differentiated Services (Diff-Serv) configuration information. This information includes the node level PHB-EXP mapping configured for ELSP-signaled LSP.

Command Syntax

```
show rsvp diffserv-info
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

Following is a sample output of the `show rsvp diffserv-info` command.

```
#show rsvp diffserv-info
CLASS-EXP mapping:
CLASS      DSCP_value
c5  101000 0
be  000000 1
cs1 001000 2
cs3 011000 3
cs2 010000 4
cs4 100000 5
cs6 110000 6
cs7 111000 7
```

[Table 2-1](#) explains the show command output fields.

Table 2-1: show rsvp diffserv-info output fields

Field	Description
CLASS	MPLS class type that corresponds to the DiffServ traffic engineering class.
EXP_value	Exp value is initialized at the ingress routing device only and overrides the rewrite configuration established for that forwarding class.

CHAPTER 3 Virtual Private LAN Service Commands

This chapter describes each VPLS (Virtual Private LAN Service) command.

- [ac-admin-status](#)
- [ac-description](#)
- [clear mpls vpls](#)
- [control-word](#)
- [exit-signaling](#)
- [exit-if-vpls](#)
- [learning disable \(VPLS Mode\)](#)
- [learning disable \(Interface VPLS Mode\)](#)
- [learning enable](#)
- [no learning](#)
- [mpls vpls](#)
- [mpls-vpls service-template](#)
- [show mpls vpls](#)
- [show mpls vpls mac-address](#)
- [show mpls vpls split-horizon](#)
- [show mpls vpls statistics](#)
- [signaling ldp](#)
- [signaling bgp](#)
- [split-horizon \(service-template\)](#)
- [static-mac](#)
- [tunnel-select-policy](#)
- [ve-id](#)
- [vpls-ac-group](#)
- [vpls-description](#)
- [vpls fib-entry](#)
- [vpls-mtu](#)
- [vpls-peer](#)
- [vpls-peer manual](#)
- [vpls-type](#)
- [vpls-vc](#)

ac-admin-status

Use this command to configure the admin status of an attachment circuit specific to a VPLS instance.

Command Syntax

```
ac-admin-status down
no ac-admin-status
```

Parameter

down	set the admin role as DOWN
------	----------------------------

Default

By default, ac admin status is up

Command Mode

Interface VPLS

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows the configuration of admin status for attachment circuit specific to VPLS instance

```
#configure terminal
(config)#interface xe1
(config-if)#mpls-vpls vpls1 service-template st1
(config-if-vpls)#no ac-admin-status
```

ac-description

Use this command to add description for an attachment circuit specific for a VPLS instance

Use the no parameter with this command to remove the description

Command Syntax

```
ac-description LINE
```

Parameter

LINE	Characters describing this AC
------	-------------------------------

Default

By default, ac description LINE is disabled

Command Mode

Interface VPLS

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows the configuration of description for attachment circuit specific to VPLS instance

```
#configure terminal
(config)#interface xe1
(config-if)#mpls-vpls vpls1 service-template st1
(config-if-vpls)#ac-description AC1_VPLS1
```

clear mpls vpls

Use this command to clear VPLS data.

Command Syntax

```
clear mpls vpls (NAME |) mac-addresses
```

Parameters

NAME	Clear data for the VPLS instance with name given
mac-addresses	Flush all MAC addresses for a VPLS instance

Command Mode

Exec mode and privileged exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#clear mpls vpls VPLS_123 mac-addresses
```

control-word

Use this command to enable control-word for a VPLS instance.

Use the `no` parameter with this command to disable control-word.

Command Syntax

```
control-word
no control-word
```

Parameters

None

Default

By default, control-word is disabled.

Command Mode

VPLS mode

Applicability

This command was introduced in OcNOS version 4.1.

Example

```
#(config-vpls)#control-word
#(config-vpls)#no control-word
```

exit-signaling

Use this command to exit the VPLS signaling configuration mode, and start signaling. To configure signaling with LDP, see the [signaling ldp](#) command. Other VPLS signaling configuration commands include [show mpls vpls](#), [show mpls vpls](#), [vpls-vc](#), [vpls-ac-group](#), and [vpls-peer](#).

Note: It is *critical* to give this command after all VPLS signaling configurations are complete, otherwise signaling does not start.

Command Syntax

```
exit-signaling
```

Parameters

None

Default

No default value is specified

Command Mode

VPLS Signaling mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
# configure terminal
(config)#mpls vpls test 100
(config-vpls)#signaling ldp
(config-vpls-sig)#exit-signaling
```

exit-if-vpls

Use this command to exit from Interface VPLS mode

Command Syntax

```
exit-if-vpls
```

Parameter

None

Default

No default value is specified

Command Mode

Interface VPLS

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows exiting from interface VPLS mode

```
#configure terminal
(config)#interface xe1
(config-if)#mpls-vpls vpls1 service-template st1
(config-if-vpls)#ac-description AC1_VPLS1
(config-if-vpls)#exit-if-vpls
(config-if-vpls)#exit
```

learning disable (VPLS Mode)

Use this command to disable learning for a VPLS instance.

Use the `no` form of this command to enable learning on a VPLS instance.

Note: This command disables learning on all the attachment circuits and pseudo-wires belonging to that VPLS instance.

Command Syntax

```
learning disable
no learning disable
```

Parameter

None

Default

By default, learning disable is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config-vpls)#mpls vpls vpls2 vlan 3
(config-vpls)#learning disable
(config-vpls)#exit

#configure terminal
(config-vpls)#mpls vpls vpls2 vlan 3
(config-vpls)#no learning disable
(config-vpls)#exit
```

learning disable (Interface VPLS Mode)

Use this command to disable learning on a particular Attachment Circuit (AC) interface.

Use the [learning enable](#) command to enable learning on a particular AC interface.

Note: This command disables MAC learning only on that interface.

Command Syntax

```
learning disable
```

Parameter

None

Default

By default, learning disable is disabled

Command Mode

Interface VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#mpls-vpls vpls1 service-template st1
(config-if-vpls)#learning disable
(config-if-vpls)#exit
```

learning enable

Use this command to enable learning on a particular attachment circuit (AC) interface.

Use the [learning disable \(Interface VPLS Mode\)](#) command to disable learning on a particular AC interface.

Note: This command enables MAC learning only on that AC interface.

Command Syntax

```
learning enable
```

Parameter

None

Default

By default, learning enable is enabled

Command Mode

Interface VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#mpls-vpls vpls1 service-template st1
(config-if-vpls)#learning enable
(config-if-vpls)#exit
```

no learning

Use this command to reset learning on a particular AC-interface to the global learning configuration.

Command Syntax

```
no learning
```

Parameter

None

Default

By default, no learning is disabled

Command Mode

Interface VPLS mode and VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#mpls-vpls vpls1 service-template st1
(config-if-vpls)#no learning
(config-if-vpls)#exit
(config)#
```

```
#configure terminal
(config)#mpls vpls vpls5 vlan 34
(config-vpls)#learning limit 500
(config-vpls)#exit
(config)#
```

mpls vpls

Use this command to create an instance of MPLS-based Virtual Private LAN Services (VPLS).

Use the `no` parameter with this command to delete an MPLS-based VPLS instance.

Command Syntax

```
mpls vpls NAME
mpls vpls NAME <1-4294967295>
no mpls vpls NAME
```

Parameters

NAME	VPLS instance identifier
<1-4294967295>	VPLS instance identifier

Default

By default, `mpls vpls` is disabled

Command Mode

Configuration mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls vpls t1 6489
(config-vpls)#exit
```

mpls-vpls service-template

Use this command to bind a VPLS instance to a service template.

Use the no parameter with this command unbind the VPLS instance from service template.

Command Syntax

```
mpls-vpls VPLS_NAME service-template TEMPLATE_NAME
no mpls-vpls VPLS_NAME service-template TEMPLATE_NAME
```

Parameters

VPLS_NAME	VPLS instance name
TEMPLATE_NAME	Service template name

Default

N/A

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth1
(config-if)#switchport
(config-if)#mpls-vpls VPLS1 service-template C1
(config-if-vpls)#exit-if-vpls

(config-if)#no mpls-vpls VPLS1 service-template C1
(config-if)#exit-if-vpls
```

show mpls vpls

Use this command to display logging information configured for MPLS.

Command Syntax

```
show mpls vpls
show mpls vpls debug-detail
show mpls vpls detail
show mpls vpls mesh
show mpls vpls NAME
show mpls vpls NAME mesh
show mpls vpls NAME spoke
show mpls vpls spoke
show mpls vpls count
```

Parameters

debug-detail	Show detailed VPLS information for debugging purpose
detail	Display detailed VPLS information
mesh	Display MPLS VPLS Mesh Forwarding information. Use this parameter to display information about all core Virtual Circuit (VC) connections for all VPLS instances. Give the name of a VPLS instance to display information about that instance.
NAME	Display the identifying string for the VPLS domain
spoke	Display MPLS VPLS Spoke Forwarding information. Use this parameter to display information about all spoke VC connections for all VPLS instances. Give the name of a VPLS instance to display information about that instance.
count	Display the count of VPLS instances

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Examples

Using `show mpls vpls` command without parameters displays information about all VPLS instances.

The example below displays information about the VPLS instance `v1`, returned when using the `NAME` parameter.

```
#show mpls vpls t1
Virtual Private LAN Service Instance: t1, ID: 1
Group ID: 0, VPLS Type: Ethernet VPLS, Configured MTU: 0
Description: none
Configured interfaces: none
Mesh Peers: 192.168.0.80 (Up)
             192.168.0.90 (Up)
Spoke Peers: t100 (Up)
```

#

Table 3-2 explains the show command output fields.

Table 3-2: show mpls vpls t1 output field

Field	Description
Virtual Private LAN Service Instance	Number of VPLAN service instance.
ID	VPLAN identification detail for service instance.
Group ID	Group identification detail for VLAN.
VPLS Type	Type of VPLS in the interface.
Configured MTU	Number of configured MTU in the VPLs.
Description	Details of VPLS.
Configured interfaces	Description of the configured interfaces.
Mesh Peers	Configuring the VPLS mesh peers.
Spoke Peers	Configuring the VPLS spoke peers.

The example below displays the name of the VPLS instance, its ID, the type of instance (Ethernet), the M and S peers, and the signaling protocol. For the first entry, the signaling protocol is BGP and for the second entry it is LDP.

```
#show mpls vpls
Name  VPLS-ID      Type           MPeers    SPeers    SIG-Protocol
v1    100           Ethernet       1          0         BGP
v3    300           Ethernet       1          0         LDP
```

Table 3-3 explains the show command output fields.

Table 3-3: show mpls vpls output field

Field	Description
Name	Type of the MPLS protocol.
VPLS-ID	Identification detail of VPLS.
Type	Type of VPLS in MPLS protocol.
Mesh Peers	Configuring the VPLS mesh peers.
Spoke Peers	Configuring the VPLS spoke peers.
SIG-Protocol	Type of protocol in MPLS configuration.

The example below displays the output when using the debug-detail parameter. It displays information for VPLS instance `vp1s1`, including the signaling protocol, create time, uptime, total down time, associated transport, traffic statistics if non-zero and statistics profile enabled, and so on.

```
#show mpls vpls debug-detail
Virtual Private LAN Service Instance: vp1s1, ID: 300
  SIG-Protocol: LDP
  Attachment-Circuit: UP
  Learning: Enabled
  Control-Word: Disabled
  Flow Label Status: Disabled, Direction: None, Static: No
  Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
  Description: none
  service-tpid: dot1.q
  Operating mode: Tagged
  Svlan Id: 0
  Svlan Tpid: 8100

Configured interfaces:
  Interface: xe4
  Status: Up
  Service-template : vp1s1
  Match criteria : 440

Mesh Peers:
  2.2.2.2 State: Installed
    CreateTime: 08:56:53, UpTime: 08:56:53
    TotalDownTime: N/A, FlapCount: 0, LastFlapReason: N/A
    Tunnel-Id: 11
    Transport: owner CLI, ftn_ix 9
  3.3.3.3 State: Installed
    CreateTime: 08:56:53, UpTime: 08:56:53
    TotalDownTime: N/A, FlapCount: 0, LastFlapReason: N/A
    Tunnel-Name: t1
    Transport: owner RSVP, ftn_ix 8
  4.4.4.4 State: Installed
    CreateTime: 08:56:53, UpTime: 08:49:39
    TotalDownTime: 00:01:11, FlapCount: 1, LastFlapReason: FIB delete from
protocol
    Tunnel-Policy: p1
    Transport: owner SR_POLICY, ftn_ix 13
```

The example below displays the output when using the detail parameter. It displays information for VPLS instance `v1`, including the signaling protocol.

```
#show mpls vpls detail
Virtual Private LAN Service Instance: vp1s1, ID: 10
  SIG-Protocol: LDP
  Attachment-Circuit :UP
  Learning: Enabled
  Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
  Description: none
  service-tpid: dot1.q
  Operating mode: Tagged
  Svlan Id: 0
  Svlan Tpid: 8100
```

```

Configured interfaces:
Interface: xe39

Service-template : t1
Match criteria : Accept all
Mesh Peers:
2.2.2.2 (Up)

```

Table 3-4 explains the show command output fields.

Table 3-4: show mpls vpls details output field

Field	Description
Virtual Private LAN Service Instance	Number of VPLS service instance.
ID	VPLS identification detail for service instance.
SIG-Protocol	Type of protocol in MPLS configuration.
Attachment-Circuit	Details of the attached circuit in interface.
Learning	State of the interface.
Group ID	Group identification detail for VLAN.
VPLS Type	Type of VPLS in MPLS protocol.
Configured MTU	Number of configured MTU in the VPLs.
Description	Details of VPLS.
Service-tpid	Service TP identifier configured for the VPLS PW.
Operating mode	Type of mode in the interface.
Svlan Id	Configures a specific virtual LAN (VLAN).
Svlan Tpid	Service vlan TP identifier for the VPLS PW.
Redundancy admin role	Creating a Backup Administrator Role.
Redundancy oper role	Operational Role of the VPLS instance.
Configured interfaces	Details of the configured interfaces.
Interface	Selects an interface to configure.
Oper-state	Displays the current status of the cross-connect segment – Up or Down.
Service-template	Used to configure advanced service-related option.
Match criteria	Identifies prefix characteristics (network, BGP path attribute, nexthop, and so on) for a specific sequence.
Mesh Peers	Configuring the VPLS mesh peers.

Table 3-4: show mpls vpls details output field

Field	Description
PW Status Local	Used to perform limited local configuration changes, monitor device status and utilization, and simple local troubleshooting.
Remote	PW status of Remote end.

The example below displays the output provided when using the `mesh` parameter without a specific VPLS name.

```

VPLS-ID  Peer Addr Tunnel-Label In-Label Network-Intf Out-Label Lkps/St PW-
INDEX    SIG-Protocol
100      2.2.2.2   N/A           52503    eth2         53258      0/Dn
2        BGP
300      2.2.2.2   N/A           none     N/A          none       0/Dn
1        LDP

```

[Table 3-5](#) explains the show command output fields.

Table 3-5: show mpls vpls output field

Field	Description
VPLS-ID	Identification details of the VPLS.
Peer Addr	IP address of the peer device.
Tunnel-Label	Tunnel label used for the next segment.
In-label	Displays the ingress (incoming interface) label for this segment.
Out-Label	Label received from downstream neighbor for route.
Network-Intf	Installed as a result of configuring an interface.
Lkps/St	Opcode and Status of the VPLS PW.
PW-INDEX	Index of the VPLS entry in PW table.
SIG-Protocol	Signaling protocol used for VPLS labels advertisement.

The following is a sample output of the `show mpls vpls detail` command displaying detailed information about all configured VPLS instances.

```

#show mpls vpls detail
Virtual Private LAN Service Instance: vpls3100, ID: 3100
SIG-Protocol: BGP
Route-Distinguisher :65010:3100
Route-Target :65010:3100
VE-ID :31
Attachment-Circuit :UP
Learning: Enabled
Group ID: 0, Configured MTU: 9216
Description: none

```

```

service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
Interface: xe26
Service-template : vpls3100_3100_13100
Match criteria : 3100
Action type : Translate
Action value : 4075
Outgoing tpid : dot1.q

Mesh Peers:
2.2.2.2 (Up)

```

Table 3-6 explains the show command output fields.

Table 3-6: show mpls vpls details output field

Field	Description
Virtual Private LAN Service Instance	Number of VPLS service instance.
ID	VPLS identification detail for service instance.
SIG-Protocol	Type of protocol in MPLS configuration.
Attachment-Circuit	Details of the attached circuit in interface.
Learning	State of the interface.
Group ID	Group identification detail for VLAN.
VPLS Type	Type of VPLS in MPLS protocol.
Configured MTU	Number of configured MTU in the VPLs.
Description	Details of VPLS.
Service-tpid	Service TP identifier configured for the VPLS PW.
Operating mode	Type of mode in the interface.
Svlan Id	Configures a specific virtual LAN (VLAN).
Svlan Tpid	Service vlan TP identifier for the VPLS PW.
Redundancy admin role	Creating a Backup Administrator Role.
Redundancy oper role	Operational Role of the VPLS instance.
Configured interfaces	Details of the configured interfaces.
Interface	Selects an interface to configure.
Oper-state	Displays the current status of the cross-connect segment – Up or Down.
Service-template	Used to configure advanced service-related option.

Table 3-6: show mpls vpls details output field

Field	Description
Match criteria	Identifies prefix characteristics (network, BGP path attribute, nexthop, and so on) for a specific sequence.
Mesh Peers	Configuring the VPLS mesh peers.
PW Status Local	Used to perform limited local configuration changes, monitor device status and utilization, and simple local troubleshooting.
Remote	PW status of Remote end.

The following is a sample output of the `show mpls vpls mesh` command displaying information about all the core VC connections for all VPLS instances.

```
#show mpls vpls mesh
VPLS-ID    Peer Addr      In-Intf    In-Label    Out-Intf    Out-Label    Lkps/St
PW-INDEX  SIG-Protocol  Status    Ecmp-Group
1          192.168.0.80  eth0       16          eth0        640          1/Up
1          BGP Active    N/A
1          192.168.0.90  eth1       18          eth1        642          1/Up
2          BGP Active    N/A
2          192.168.0.80  eth0       19          eth0        641          1/Up
1          BGP Active    N/A
2          192.168.0.90  eth1       17          eth1        643          1/Up
2          BGP Active    N/A
#
```

Table 3-7 explains the show command output fields.

Table 3-7: show mpls vpls mesh output field

Field	Description
VPLS-ID	Identification details of the VPLS.
Peer Addr	IP address of the peer device.
In-Intf	Installed as a result of configuring an interface.
In-label	Displays the ingress (incoming interface) label for this segment.
Out-Label	Label received from downstream neighbor for route.
Network-Intf	Installed as a result of configuring an interface.
Lkps/St	Opcode and Status of the VPLS PW.
PW-INDEX	Pseudo wire index
SIG-Protocol	Signalling protocol
Status	Status of Pseudo wire
Ecmp-Group	Equal cost multi path group

The following is a sample output of the `show mpls vpls spoke` displaying the spoke VC connection to the VPLS instance.

```
#show mpls vpls spoke
VPLS-ID      Virtual Circuit In-Intf      In-Label    Out-Intf    Out-Label  Lkps/St
1            t100             eth2         20          eth2        640        1/Up
#
```

Table 3-8 explains the show command output fields.

Table 3-8: show mpls vpls spoke output field

Field	Description
VPLS-ID	Identification details of the VPLS.
Virtual Circuit	Used in transportation of data over a packet switch computer network.
In-Intf	Installed as a result of configuring an interface.
In-label	Displays the ingress (incoming interface) label for this segment.
Out-Label	Label received from downstream neighbor for route.
Network-Intf	Installed as a result of configuring an interface.
Lkps/St	Opcode and Status of the VPLS PW.

The following is a sample output of `show mpls vpls count` displaying information about total, active and inactive vpls instances.

```
#show mpls vpls count
-----
Total VPLS instances      : 2
Active VPLS instances     : 2
Inactive VPLS instances   : 0
-----
```

Table 3-9 explains the show command output fields.

Table 3-9: show mpls vpls count output field

Field	Description
Total VPLS instances	Number of total VPLS instance.
Active VPLS instances	Number of active VPLS instance.
Inactive VPLS instances	Number of inactive VPLS instance.

show mpls vpls mac-address

Use this command to display retrieved VPLS learning mac-addresses on MPLS enabled node.

Command Syntax

```
show mpls vpls mac-address (name NAME |) (interface IFNAME |) (peer A.B.C.D |)
(count |)
```

Parameters

NAME	Specify the name of the vpls instance
count	Counts the number of MAC address learned
IFNAME	Specify the name of interface
A.B.C.D	Specify the peer address

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#show mpls vpls mac-address
VPLS-ID      MAC address      Learned from      Peer address
1            08:00:27:85:28:8a  eth1              1.1.1.1
1            08:00:27:99:91:1d  eth3              -
```

```
#show mpls vpls mac-address count
Total no of MAC addresses learnt :2
```

```
#show mpls vpls mac-address name vpls1
MAC address      Learned from      Peer address
08:00:27:85:28:8a  eth1              1.1.1.1
08:00:27:99:91:1d  eth3              -
```

```
#show mpls vpls mac-address name vpls1 count
Total no of MAC addresses learnt :2
```

```
#show mpls vpls mac-address interface eth1
VPLS-ID      MAC address      Learned from      Peer address
1            08:00:27:85:28:8a  eth1              1.1.1.1
```

```
#show mpls vpls mac-address interface eth1 count
Total no of MAC addresses learnt :1
```

```
#show mpls vpls mac-address name vpls1 interface eth1
MAC address      Learned from    Peer address
08:00:27:85:28:8a  eth1              1.1.1.1
```

```
#show mpls vpls mac-address name vpls1 interface eth1 count
Total no of MAC addresses learnt :1
```

```
#show mpls vpls mac-address peer 1.1.1.1
VPLS-ID    MAC address      Learned from    Peer address
1          08:00:27:85:28:8a  eth1            1.1.1.1
```

```
#show mpls vpls mac-address peer 1.1.1.1 count
Total no of MAC addresses learnt :1
```

```
#show mpls vpls mac-address name vpls1 peer 1.1.1.1
MAC address      Learned from    Peer address
08:00:27:85:28:8a  eth1            1.1.1.1
```

```
#show mpls vpls mac-address name vpls1 peer 1.1.1.1 count
Total no of MAC addresses learnt :1
```

```
#show mpls vpls mac-address interface eth1 peer 1.1.1.1
VPLS-ID    MAC address      Learned from    Peer address
1          08:00:27:85:28:8a  eth1            1.1.1.1
```

```
# show mpls vpls mac-address interface eth1 peer 1.1.1.1 count
Total no of MAC addresses learnt :1
```

```
#show mpls vpls mac-address name vpls1 interface eth1 peer 1.1.1.1
MAC address      Learned from    Peer address
08:00:27:85:28:8a  eth1            1.1.1.1
```

```
#show mpls vpls mac-address name vpls1 interface eth1 peer 1.1.1.1 count
Total no of MAC addresses learnt :1
```

Table 3-10 explains the show command output fields.

Table 3-10: show mpls vpls mac-address output field

Field	Description
MAC address	Used to forward the packet into a given VPLS instance.
Learned from	MAC addresses learned from a specific interface.
Peer address	IP address of the peer device.

show mpls vpls split-horizon

Use this command to display the split horizon grouping information.

Command Syntax

```
show mpls vpls split-horizon <vpls_name>
```

Parameters

<vpls_name> (Optional). Specifies the name of the VPLS.

Default

None

Command Mode

EXEC mode

Applicability

This command was introduced before OcNOS version 6.5.2.

Example

The following example shows a summary of all VPLS instances, showing their VPLS ID, type, details (such as spokes or ACs), associated interfaces, and the split horizon group they belong to:

```
#show mpls vpls split-horizon
+-----+-----+-----+-----+-----+
| VPLSID | Type | Details | Interface | Group |
+-----+-----+-----+-----+-----+
| 800    | AC   | st2     | xe9       | access2 |
| 800    | AC   | -       | xe17.800  | access1 |
| 800    | Spoke | vc2     | -         | network |
| 2000   | Spoke | vc1     | -         | access1 |
```

The following example shows the split horizon details for a specific VPLS instance, showing similar information but focused on the specified VPLS ID:

```
#show mpls vpls split-horizon vpls800
+-----+-----+-----+-----+-----+
| VPLSID | Type | Details | Interface | Group |
+-----+-----+-----+-----+-----+
| 800    | AC   | st2     | xe9       | access2 |
| 800    | AC   | -       | xe17.800  | access1 |
| 800    | Spoke | vc2     | -         | network |
```

The following example shows when there is no VPLS is configured with the specified VPLS ID:

```
#show mpls vpls split-horizon vpls200
% No VPLS with name: vpls200 configured.
```

The following example shows VPLS split horizon details for VPLS ID 2000:

```
#show mpls vpls split-horizon vpls2000
+-----+-----+-----+-----+-----+
```

VPLSID	Type	Details	Interface	Group
2000	Spoke	vc1	-	access1

Table 3-10 explains the show command output fields.

Table 3-11: show mpls vpls split-horizon output field

Field	Description
VPLSID	The ID of the VPLS instance. It uniquely identifies each VPLS in the network.
Type	The type of connection within the VPLS instance.
Details	Additional details about the VPLS connection type, such as the virtual circuit (VC) number or other identifiers related to the connection.
Interface	The physical or logical interface on the PE router that is part of the VPLS instance.
Group	The split-horizon group associated with the VPLS instance.

show mpls vpls statistics

Use this command to display MPLS traffic statistics for VPLS network or access or all ports.

Note: Multicast traffic statistics not supported by hardware.

Command Syntax

```
show mpls vpls NAME statistics
show mpls vpls NAME statistics ((network-port ((peer A.B.C.D) |(spoke-vc VC-NAME) |))
| (access-port (IFNAME (ethernet|(vlan <1-4094>)) |)))
```

Parameters

NAME	Name of the VPLS instance
a.b.c.d	Mesh peer address of VC instance
VC-NAME	Name of the spoke VC instance
IFNAME	Name of the access-port interface
<1-4094>	VLAN ID of access-port of type VLAN

Command Mode

Exec mode and privileged exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls vpls v1 statistics
Virtual Private LAN Service Instance: v1, ID: 10

Access port statistics:
Interface: xe3/4 VLAN ID: 2
  RX:  Input packets   : 10
      Input bytes      : 640
  TX:  Output packets  : 0
      Output bytes     : 0

Network port statistics:
Mesh Peer: 8.8.8.8 (Up)
  RX:  Input packets   : 0
      Input bytes      : 0
  TX:  Output packets  : 10
      Output bytes     : 640
```

[Table 3-10](#) explains the show command output fields.

Table 3-12: show mpls vpls statistics output field

Field	Description
Access port statistics	Traffic statistics on Access port of VC/VPLS.
Network port statistics	Traffic statistics on Provider port of VC/VPLS.
Interface	Type of interface in the network.
VLAN ID	Identification details of the VPLS.
Mesh Peer	Configuring the VPLS mesh peers.
RX	Number of received packets.
Input packets	Number of hello packets received from the neighbor.
Input bytes	Size of hello packets received from the neighbor.
TX	Number of packets transmitted.
Output packets	Number of hello packets sent to the neighbor.
Output bytes	Size of hello packets sent to the neighbor.

signaling ldp

Use this command to establish a pseudowire connection between Provider Edge (PE) routers. Use this command to use the Label Distribution Protocol (LDP) for signaling and to support VPLS auto-discovery between VPLS instances. Using this command triggers LDP to signal a pseudowire between the configured VPLS peers in the same VPLS instance. The `vpls-peer` command is used to identify the VPLS peers that are part of a VPLS instance.

Note: Issuing this command puts the router into VPLS signaling (`config-vpls-sig`) mode.

Use the `no` parameter with this command to remove (tear down) pseudowires with other PE routers.

Command Syntax

```
signaling ldp
no signaling ldp
```

Parameters

None

Default

By default, signaling ldp is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)# mpls vpls test 100
(config-vpls)#signaling ldp
(config-vpls-sig)#vpls-peer 97.97.97.97
(config-vpls-sig)#exit
```

signaling bgp

Use this command to establish a pseudowire connection between Provider Edge (PE) routers. Use this command to use the Border Gateway Protocol (BGP) for signaling and to support VPLS auto-discovery between VPLS instances. Using this command triggers BGP to auto-discover VPLS peers and signal pseudowire between the VPLS peers in the same VPLS instance.

Note: Issuing this command puts the router into VPLS signaling .

Use the `no` parameter with this command to remove (tear down) pseudowires with other PE routers.

Command Syntax

```
signaling bgp
no signaling bgp
```

Parameters

None

Default

By default, signaling bgp is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)# mpls vpls test 100
(config-vpls)#signaling bgp
(config-vpls-sig)#exit
```

signaling bgp

Use this command to establish a pseudowire connection between Provider Edge (PE) routers. Use this command to use the Border Gateway Protocol (BGP) for signaling and to support VPLS auto-discovery between VPLS instances. Using this command triggers BGP to auto-discover VPLS peers and signal pseudowire between the VPLS peers in the same VPLS instance.

Note: Issuing this command puts the router into VPLS signaling .

Use the `no` parameter with this command to remove (tear down) pseudowires with other PE routers.

Command Syntax

```
signaling bgp
no signaling bgp
```

Parameters

None

Default

By default, signaling bgp is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)# mpls vpls test 100
(config-vpls)#signaling bgp
(config-vpls-sig)#exit
```

split-horizon (service-template)

Use this command to configure split-horizon group for vpls attachment circuit.

Use the `no` form of this command to remove split-horizon group from vpls attachment circuit.

Command Syntax

```
split-horizon group (network | access1 | access2)
no split-horizon group
```

Parameters

<code>network</code>	Split-horizon group name network
<code>access1</code>	Split-horizon group name access1
<code>access2</code>	Split-horizon group name access2

Default

By default, split horizon is disabled.

Command Mode

Interface VPLS mode

Applicability

This command was introduced before OcNOS version 6.3.0 and applicable only on Qumran1 devices.

Examples

```
#configure terminal
(config)#interface xe1
(config-if)#switchport
(config-if)#mpls-vpls vpls1 service-template vc1
(config-if-vpls)#split-horizon group access1
(config-if-vpls)#no split-horizon group
```

static-mac

Use this command to add static MAC address to attachment circuit specific for a VPLS instance.

Use the `no` parameter with this command to remove static MAC address.

Note: It is not supported, if the user configures same mac address on different attachment circuits for same VPLS instance.

Command Syntax

```
static-mac XXXX.XXXX.XXXX  
no static-mac XXXX.XXXX.XXXX
```

Parameter

XXXX.XXXX.XXXX MAC address in HHHH.HHHH.HHHH format.

Default

By default, mac is disabled

Command Mode

Interface VPLS

Applicability

This command was introduced before OcNOS version 4.2.

Examples

```
(config)#interface cell/2  
(config-if)#mpls-vpls vpls2 service-template vc1  
(config-if-vpls)#static-mac 0000.0400.0602
```

tunnel-select-policy

Use this command to set tunnel-policy for a VPLS instance. This command is used for BGP signaling based VPLS instance. This will be used while selecting transport for the peer.

Use the `no` parameter with this command to un-configure tunnel selection policy.

Command Syntax

```
tunnel-select-policy TNLPOLICYNAME
no tunnel-select-policy
```

Parameters

 TNLPOLICYNAME Name of tunnel policy

Command Mode

VPLS SIG mode

Applicability

This command was introduced before OcNOS version 4.2.

Examples

```
#configure terminal
(config)#mpls vpls vpls1 10
(config-vpls)#signaling bgp
(config-vpls-sig)#tunnel-select-policy policy1
```

ve-id

Use this command to configure a VPLS Edge (VE) device. Each Provider Edge (PE) device participating in a VPLS must have at least one VE ID. When the PE is connected to several u-PEs (Layer 2 PE devices used to provide Layer 2 aggregation), there are unique VE ID's for each u-PE. The PE may also be assigned a VE ID, if it is to act as the VE for the VPLS.

Use the `no` parameter with this command to remove a VE ID.

Command Syntax

```
ve-id <1-65535>
no ve-id <1-65535>
```

Parameters

<1-65535>	VE-ID's range is between 1 and 65535. This should be unique among the VPLS Peers for a VPLS instance.
-----------	---

Default

By default, `ve id` is disabled

Command Mode

BGP VPLS Signaling mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls vpls test 100
(config-vpls)#signaling bgp
(config-vpls-sig)#ve-id 2
(config-vpls-sig)#exit
```

vpls-ac-group

Use this command to assign an Attachment Circuit (AC) group to VPLS.

Use the `no` parameter with this command to remove an AC group.

Command Syntax

```
vpls-ac-group GROUPNAME  
no vpls-ac-group
```

Parameter

GROUPNAME	Enter a name for the AC group
-----------	-------------------------------

Default

By default, vpls ac group is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal  
(config)#mpls vpls test 12  
(config-vpls)#vpls-ac-group new-ac  
(config-vpls)#no vpls-ac-group
```

vpls-description

Use this command to add a description line for a VPLS instance.

Use the `no` parameter with this command to remove a VPLS description.

Command Syntax

```
vpls-description LINE
no vpls-description (LINE|)
```

Parameter

LINE	Enter a text string for the VPLS instance
------	---

Default

By default, vpls description is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls vpls test 34
(config-vpls)#vpls-description This is for testing
(config-vpls)#exit
```

vpls fib-entry

Use this command to create a static VPLS FIB entry. When a VPLS peer is configured manually, no signaling is done. Therefore, a VPLS static entry must be created for all manually created nodes.

Use the `no` option with this command to delete a static VPLS FIB entry.

Command Syntax

```
vpls fib-entry VPLS-ID (peer A.B.C.D| spoke-vc VC-NAME) IN-LABEL OUT-INTF OUT-LABEL
no vpls fib-entry VPLS-ID ((peer A.B.C.D) | (spoke-vc VC-NAME))
no vpls fib-entry VPLS-ID ((peer A.B.C.D) | (spoke-vc VC-NAME)) IN-LABEL OUT-INTF
OUT-LABEL
```

Parameters

VPLS-ID	VPLS identifier
peer	Mesh peer address VPLS identifier
A.B.C.D	Peer IPv4 Address.
spook-vc	Spoke VC
VC-NAME	Virtual Circuit name
IN-LABEL	Incoming label value in the range of <16-15999>
OUT-INTF	Provider-facing interface
OUT-LABEL	Outgoing label value in the range of <16-15999>

Default

By default, vpls fib entry is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The first example shows how to configure VPLS FIB entry 100 with mesh peer 97.97.97.97 for incoming label 15999, outgoing interface eth2 with outgoing label 15999:

```
#configure terminal
(config)#vpls fib-entry 100 peer 97.97.97.97 15999 eth2 15999
```

The second example shows how to configure VPLS FIB entry 100 with spoke-vc t1 for incoming label 15999, outgoing interface eth2 with outgoing label 15999:

```
#configure terminal
(config)#vpls fib-entry 100 spoke-vc t1 15999 eth2 15999
```

vpls-mtu

Use this command to set the Maximum Transmission Unit (MTU) size for a given VPLS instance. This size is signaled to peer VPLS routers.

Use the `no` parameter with this command to remove the MTU size setting.

Command Syntax

```
vpls-mtu <576-65535>
no vpls-mtu (<576-65535>|)
```

Parameter

`<576-65535>` Range of MTU size allowed for a VPLS instance

Default

By default, vpls mtu is 1500

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls vpls test 34
(config-vpls)#vpls-mtu 6506
(config-vpls)#exit
```

vpls-peer

Use this command to add a peer to a VPLS domain. This command triggers Label Distribution Protocol (LDP) signaling by default.

Use the **no** parameter to delete a VPLS virtual circuit for a specific peer.

Use the **no** parameter to delete a VPLS tunnel mapping for a specific peer to delete/unmap tunnel-id, tunnel-name or tunnel-select-policy for a vpls-peer.

Command Syntax

```
vpls-peer A.B.C.D ((agi NAME saii NAME taii NAME) |) ((tunnel-id <1-5000>) |
(tunnel-name TNLNAME) |) ((tunnel-select-policy TNLPOLICYNAME)|)
no vpls-peer A.B.C.D ((tunnel-id | tunnel-name | tunnel-select-policy) |)
```

Parameters

A.B.C.D	The address of a VPLS peer node to which a mesh virtual circuit is to be created
tunnel-id	Static Tunnel Identifier
<1-5000>	Identifying value for Tunnel-id
A.B.C.D	IPv4 Address for end-point for FEC129 MPLS Layer-2 Virtual Circuit
agi	Specify the value used for the AGI in FEC129 MPLS Layer-2 Virtual Circuit
NAME	AGI value for FEC129 MPLS Layer-2 Virtual Circuit
saii	Specify the value used for the SAI in FEC129 MPLS Layer-2 Virtual Circuit
NAME	SAI value for FEC129 MPLS Layer-2 Virtual Circuit
taii	Specify the value used for the TAI in FEC129 MPLS Layer-2 Virtual Circuit
NAME	TAI value for FEC129 MPLS Layer-2 Virtual Circuit
tunnel-name	Tunnel name of the MPLS LSP (or Layer 2 Tunnel) to be used
TUNNELNAME	Identifying name for Tunnel
tunnel-select-policy	Tunnel selection policy
TNLPOLICYNAME	Name of tunnel policy

Default

By default, vpls peer is disabled

Command Mode

VPLS Signaling mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls vpls test 100
(config-vpls)#signaling ldp
(config-vpls-sig)#vpls-peer 97.97.97.97
```

```
(config-vpls-sig)#vpls-peer 97.97.97.97 tunnel-id 24  
(config-vpls)#exit  
(config)#exit
```

vpls-peer manual

Use this command to statically configure a VPLS peer. Because this command is not used in signaling mode, no signaling is used to set up the virtual circuit. At least one such peer configuration is required for every VPLS instance.

Use the `no` parameter with this command to remove a statically configured VPLS peer.

Use the `no` parameter to delete a VPLS tunnel mapping for a specific peer to delete/unmap tunnel-id, tunnel-name or tunnel-select-policy for a vpls-peer.

Command Syntax

```
vpls-peer A.B.C.D ((tunnel-id <1-5000>) | (tunnel-name TNLNAME) |) (manual|)
no vpls-peer A.B.C.D ((tunnel-id | tunnel-name | tunnel-select-policy) |)
```

Parameters

A.B.C.D	The address of a VPLS peer node to which a mesh virtual circuit is to be created
tunnel-id	Static Tunnel Identifier
<1-5000>	Identifying value for Tunnel-id
tunnel-name	Tunnel name of the MPLS LSP (or Layer 2 Tunnel) to be used
TUNNELNAME	Identifying name for Tunnel

Default

By default, vpls peer A.B.C.D manual is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls vpls test 100
(config-vpls)#vpls-peer 97.97.97.97 manual
(config-vpls)#vpls-peer 97.97.97.97 tunnel-id 24 manual
(config-vpls)#exit
(config)#exit
```

vppls-type

Use this command to assign a type (either Ethernet or VLAN) for VPLS.

Note: The default type is chosen as Ethernet.

Command Syntax

```
vppls-type (ethernet|vlan)
```

Parameter

ethernet	Designate Ethernet as the VPLS type
vlan	Designate VLAN as the VPLS type

Default

By default, vppls type is ethernet

Command Mode

signaling ldp mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls vppls test 100
(config-vppls)#signaling ldp
(config-vppls-sig)#vppls-type vlan
(config-vppls-sig)#vppls-peer 2.2.2.2
(config-vppls-sig)#exit
(config-vppls)#exit
```

vppls-vc

Use this command add a spoke virtual circuit to VPLS domain.

Use the `no` parameter to remove this configuration.

Command Syntax

```
vppls-vc NAME (ethernet|vlan|)
vppls-vc NAME (secondary NAME|) (ethernet|vlan|)
no vppls-vc NAME
```

Parameter

NAME	Enter a string that identifies the MPLS VC to add to the VPLS domain
secondary	Set the secondary spoke name
NAME	Enter a string that identifies the secondary spoke
ethernet	Identify the spoke type as Ethernet (default)
vlan	Identify the spoke type as VLAN.
TNLNAME	Specify the MPLS-TP tunnel-name.

Default

By default, `vppls vc` name is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls vpls test 34
(config-vpls)#vppls-vc VC1
(config-vpls)#exit
(config)#exit
```

CHAPTER 4 EVPN MPLS Commands

This chapter describes the EVPN MPLS commands:

- `access-if-evpn`
- `arp-cache disable`
- `arp-nd cos`
- `arp-nd flood-suppress`
- `arp-nd refresh timer`
- `clear evpn mpls counters`
- `clear mac address-table`
- `dynamic-learning disable`
- `evi-name`
- `evpn esi hold-time`
- `evpn etree`
- `evpn irb`
- `evpn irb-forwarding anycast-gateway-mac`
- `evpn irb-if-forwarding anycast-gateway-mac`
- `evpn mpls enable`
- `evpn mpls id`
- `evpn mpls irb`
- `l3vni`
- `mac`
- `evpn mpls mac-ageing-time`
- `evpn mpls multihoming enable`
- `evpn mpls vtep-ip-global`
- `evpn multi-homed`
- `hardware-profile filter evpn-mpls-cw`
- `hardware-profile filter evpn-mpls-mh`
- `hardware-profile statistics evpn-mpls`
- `host-reachability-protocol`
- `ip address`
- `ipv6 address`
- `mac-holdtime`
- `mac-vrf`
- `map vpn-id`
- `nd-cache disable`
- `service-carving`
- `service-carving ac-driven`

- `service-carving weight`
- `show evpn load-balance`
- `show evpn mpls`
- `show evpn mpls arp-cache`
- `show evpn mpls counters`
- `show evpn mpls label alias`
- `show evpn mpls label esi`
- `show evpn mpls mac-table`
- `show evpn mpls nd-cache`
- `show evpn mpls route-count`
- `show evpn mpls static host state`
- `show evpn mpls status`
- `show evpn mpls tunnel`
- `show evpn mpls tunnel label`
- `show evpn mpls xconnect tunnel`
- `show evpn mpls xconnect tunnel label`
- `show running-config evpn mpls`
- `tunnel-select-policy`

access-if-evpn

Use this command to create the evpn mpls access-port.

Use the no form of this command to delete the evpn mpls access-port.

Command Syntax

```
access-if-evpn
no access-if-evpn
```

Parameters

None

Command Mode

L2 Sub-interface mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#end
```

arp-cache disable

Use this command to disable the ARP cache for MAC/IP.

When the ARP cache is disabled on a access circuit, It does not reply to any ARP arriving on this port from the cache. It withdraws all MAC/IPs configured/learned on this access circuit and removes the MAC/IP entry for this AC from the local ARP cache.

It also makes sure that on withdrawing the MAC/IP route, the MAC does not become unknown. If all routes for this MAC are being withdrawn because of this command, then It advertises a MAC-only route. This is done so that the MAC does not become unknown and only the cache functionality becomes disabled.

Use the `no` form of this command to enable ARP cache for MAC/IP.

Note: On enabling the cache, an IP will be in conflict, then the cache enable will fail. The conflict has to be manually removed and then the cache enabled.

Note: When encapsulation default is configured under L2 subifp , then arp-packets will not be uplifted.

Note: Not applicable for the AC port which is mapped with ELINE/Xconnect Service.

Command Syntax

```
arp-cache disable
no arp-cache disable
```

Parameters

None

Default

By default, the arp-cache option is enabled.

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#arp-cache disable
(config-access-if)#end
```

arp-nd cos

Use this command to explicitly set or override the COS value (0–7) in the ARP/ND reply sent (also used in ARP/ND proxy sub-feature). By default ARP/ND reply will use CoS value of received ARP/ND request.

Use the `no` form of this command to use the default COS value.

Command Syntax

```
arp-nd cos <0-7>
no arp-nd cos
```

Parameters

<0-7>

Default

CoS 0 or previous ARP/ND reply CoS being used.

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 6.5.3.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#arp-nd cos 5
(config-access-if)#end
```

arp-nd flood-suppress

Use this command to completely restrict the flood of ARP/ND packets towards remote PEs or other Access Circuit

This command applies only when the ARP cache and ND cache are enabled. When the ARP cache is disabled, ARP flooding is not suppressed even if this command is given. When the ND cache is disabled, ND flooding is not disabled, even if this command is given.

Use the `no` form of this command to not restrict the flood of ARP/ND packets.

Note: Not applicable for the AC port which is mapped with ELINE/Xconnect Service.

Command Syntax

```
arp-nd flood-suppress
no arp-nd flood-suppress
```

Parameters

None

Default

By default, the `arp-nd flood-suppress` option is disabled.

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#arp-nd flood-suppress
(config-access-if)#end
```

arp-nd refresh timer

Use this command to configure aging out the arp-cache and nd-cache entries for given time multiplied by 3 in seconds.

Use the `no` form of this command to remove the configuration.

Note: Not applicable for the AC port which is mapped with ELINE/Xconnect Service.

Note: After this timer interval, it sends out ARP to revalidate and 3 times of this would lead to removal of the dynamic entry.

Command Syntax

```
evpn mpls arp-nd refresh-timer <3-190>
no evpn mpls arp-nd refresh-timer
```

Parameters

<3-190>	Refresh timer value in seconds (age-out is refresh time * 3)
---------	--

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
#config mode
(config)#evpn mpls arp-nd refresh-timer 100
(config)#no evpn mpls arp-nd refresh-timer
```

clear evpn mpls counters

Note: Use this command to clear the counters of a network port.

Command Syntax

```
clear evpn mpls counters ((network (ingress|(egress dst <A.B.C.D>)))| vpn-id <1-16777215> (network (ingress|(egress dst <A.B.C.D>))))
```

Parameters

<1-16777215>	VPN identifier
A.B.C.D	Ipv4 address

Command Mode

Exec Mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
DUT2#clear evpn mpls counters network egress dst 105.1.1.1
DUT2#
DUT2#clear evpn mpls counters vpn-id 10 network ingress
DUT2#
```

clear mac address-table

Use this command to clear dynamically learned MACs.

Note: To make evpn mpls disable and enable effective, system reboot is required.

Command Syntax

```
clear mac address-table dynamic evpn-mpls
clear mac address-table dynamic evpn-mpls evid <1-16777215>
clear mac address-table dynamic evpn-mpls evid <1-16777215> (address MACADDR|)
```

Parameters

address	Clear the specified MAC Address
evid	EVPN-MPLS tenant identifier
<1-16777215>	Range supported for EVID

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Example

```
#clear mac address-table dynamic evpn-mpls
#clear mac address-table dynamic evpn-mpls evid 30
OcNOS#clear mac address-table dynamic evpn-mpls evid 30 address 0000.0022.2222
```

dynamic-learning disable

Use this command to disable dynamic learning of MACs at the Access Circuit.

This command also disables dynamic learning of MAC/IP from ARP/ND messages received on this Access Circuit.

Use the `no` form of this command to enable dynamic learning of MACs at the Access Circuit.

Note: Not applicable for the AC port which is mapped with ELINE/Xconnect Service.

Note: IPv4 and IPv6 addresses associated with dynamic MACs also get cleaned with this command.

Command Syntax

```
dynamic-learning disable
no dynamic-learning disable
```

Parameters

None

Default

By default, the dynamic-learning option is enabled.

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#dynamic-learning disable
(config-access-if)#end
```

evi-name

Use this command to name the EVPN MPLS ID.

Use the `no` form of this command to remove the name of the EVPN MPLS ID.

Command Syntax

```
evi-name <WORD>
no evi-name
```

Parameters

`WORD` EVI name. Maximum limit 10 characters (shall not be only numeric).

Default

None

Command Mode

EVPN MPLS mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#evpn mpls id 3
(config-evpn-mpls)#evi-name vni_ELAN
(config-evpn-mpls)#exit
```

evpn esi hold-time

Use this command to allow some time for the evpn mpls tunnels and xconnect tunnel to come at the time of evpn mpls initialization before making the ESI up. This avoids traffic to be black-holed when a new PE is added and connected to an already running CE for multi-homing.

Use the `no` form of this command to make the esi up immediately when configuring the `access-if` cli.

Command Syntax

```
evpn esi hold-time <10-300>
no evpn esi hold-time
```

Parameters

<10-300>	Hold time in seconds
----------	----------------------

Default

Default value is 0.

Command Mode

Configuration Mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)# evpn esi hold-time 100
(config)# exit
```

evpn irb

Use this command to map an IRB interface to an L2 VNID. This IRB interface can have multiple IP address as explained in IRB IP address CLI and can serve all subnets attached to the L2 VNID. Currently its 1:1 mapping between IRB interface & L2VNI.

This configuration enables default gateway behavior on that VTEP for that VNID and subnet and triggers default gateway MAC-IP route generation for the corresponding IRB IP with the local or global IRB MAC (router MAC) in distributed gateway in distributed gateway

This makes the default behavior as enable for gateway functionality.

No command disables default gateway behavior of the VTEP for that VNID subnet and triggers withdrawal of the default gateway MAC/IP advertisement done for that VNID subnet.

Use the `no` form this command to disable default gateway behavior of the VTEP for that VNID subnet and triggers withdrawal of the default gateway MAC/IP advertisement done for that VNID subnet.

Command Syntax

```
evpn irb [<NAME>|irb-advertise-host-route]
no evpn irb [<NAME>|irb-advertise-host-route]
```

Parameters

NAME	IRB interface name
irb-advertise-host-route	To advertise host IP prefixes

Command Mode

EVPN_MPLS_CONFIG Mode

Applicability

This command was introduced before OcNOS version 6.0.0.

irb-advertise-host-route introduced in OcNOS version 6.2.0.

Example

```
#config mode
(config)#evpn mpls id 10
(config-evpn-mpls)#evpn irb irb100

(config)#evpn mpls id 102
(config-evpn-mpls)#evpn irb-advertise-host-route
```

evpn irb-forwarding anycast-gateway-mac

Use this command to configure common anycast mac-address for all the IRB interfaces

Use the `no` form of this command to remove the global MAC address on all the IRB interfaces.

Command Syntax

```
evpn irb-forwarding anycast-gateway-mac MAC
no evpn irb-forwarding anycast-gateway-mac
```

Parameters

MAC	XX-XX-XX-XX-XX-XX Source MAC address (Option 1)
	XX:XX:XX:XX:XX:XX Source MAC address (Option 2)
	XXXX.XXXX.XXXX Source MAC address (Option 3)

Command Mode

Configuration Mode

Applicability

This command was introduced before OcNOS version 4.1.

Example

```
#configure terminal
(config)#evpn irb-forwarding anycast-gateway-mac 0000.0000.1313
```

Or

```
(config)#evpn irb-forwarding anycast-gateway-mac 00:00:00:00:13:13
```

Or

```
(config)#evpn irb-forwarding anycast-gateway-mac 00-00-00-00-13-13
```

```
(config)#no evpn irb-forwarding anycast-gateway-mac
```

evpn irb-if-forwarding anycast-gateway-mac

Use this command to enable a Layer 3 interface to use the global anycast IRB MAC address.

Use the `no` form of this command to unconfigure the anycast MAC at a Layer 3 interface.

Command Syntax

```
evpn irb-if-forwarding anycast-gateway-mac
no evpn irb-if-forwarding anycast-gateway-mac
```

Parameters

None

Command Mode

IRB interface mode

L3 interface mode

Applicability

This command was introduced before OcNOS version 6.0.0.

L3 interface mode support was added in OcNOS version 6.1.0.

Example

```
#configure terminal
(config)#interface irb 1
(config-irb-if)#ip vrf forwarding vrfip
(config-irb-if)#evpn irb-if-forwarding anycast-gateway-mac
(config-irb-if)#no evpn irb-if-forwarding anycast-gateway-mac
(config)#interface xe1
(config-irb-if)#ip vrf forwarding vrfip
(config-irb-if)#evpn irb-if-forwarding anycast-gateway-mac
(config-irb-if)#no evpn irb-if-forwarding anycast-gateway-mac
```

evpn mpls enable

Use this command to enable evpn mpls functionality.

Use the no version of this command to disable evpn mpls functionality.

Note: To make evpn mpls disable and enable effective, system reboot is required.

Command Syntax

```
evpn mpls enable
no evpn mpls enable
```

Parameters

None

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
(config)#evpn mpls enable
(config)#no evpn mpls enable
```

evpn mpls id

Use this command to set the VPN identifier to create an EVPN MPLS tunnel.

Note: To set the VPN identifier for an E-LAN, use the `evpn mpls id` command. For creating an E-LINE/XConnect, use the `evpn mpls xconnect` command with source and target identifiers.

Use the `no` parameter of this command to delete the EVPN MPLS ID for the MPLS tunnel.

Command Syntax

```
evpn mpls id <1-16777215> (| xconnect target-mpls-id <1-16777215>) (|control-word)
(|etree-leaf)
no evpn mpls id <1-16777215>
```

Parameters

<code>evpn mpls id</code> <code><1-16777215></code>	Specifies the EVPN-MPLS tenant identifier. This is a numeric value ranging from 1 to 16777215.
<code>xconnect</code> <code>target-mpls-</code> <code>id <1-</code> <code>16777215></code>	Enables E-LINE Xconnect. Specifies the target EVID for E-LINE Xconnect. This is a numeric value within the range from 1 to 16777215.
<code>control-word</code>	Enables control-word egress or ingress options for the given EVPN Instance (E-LAN or E-LINE). Requires the command hardware-profile filter evpn-mpls-cw to be enabled.
<code>etree-leaf</code>	(Optional) Configures the device as a leaf node within the E-Tree topology.

Command Mode

Configure mode

Applicability

Introduced in OcNOS version 3.0. Introduced `xconnect target-mpls-id <1-16777215>` parameter in the OcNOS version 4.0, `control-word` parameter in the OcNOS version 6.0.1, and `etree-leaf` parameter in the OcNOS version 6.5.1.

Example

```
(config)#evpn mpls id 10
(config-evpn-mpls)#exit

(config)#no evpn mpls id 10

(config)#evpn mpls id 100 xconnect target-mpls-id 200
(config-evpn-mpls)#exit

(config)#no evpn mpls id 100

(config)#evpn mpls id 300 xconnect target-mpls-id 400 control-word
(config-evpn-mpls)#exit

(config)#no evpn mpls id 300
```

Use the following command to configure the leaf node as an E-Tree leaf in a MPLS EVPN network.

```
(config)#evpn mpls id 10 etree-leaf  
(config-evpn-mpls)#exit
```

evpn mpls irb

Use this command to enable EVPN-MPLS-IRB globally. Applicable to EVPN-MPLS

Use the `no` form this command to disable EVPN-MPLS.

Command Syntax

```
evpn mpls irb
no evpn mpls irb
```

Parameters

None

Command Mode

Configure Mode

Applicability

This command was introduced before OcNOS version 6.0.0.

Example

```
#config mode
(config)#evpn mpls irb
(config)#no evpn mpls irb
```

l3vni

Use this command to configure L3 Virtual Network Identifier for an ip vrf

Use the no form of this command to remove L3 Virtual Network Identifier

This identifies a tenant, with this one tenant can have L3VNI as its identifier and he can have multiple L2 networks identified with L2VNI's.

Note: L3 VNID cannot be same as L2 VNID.

Command Syntax

```
l3vni <L3 VNID>
no l3vni <L3 VNID>
```

Parameters

<1-16777215> L3 VNID. Cannot be same as L2 VNID

Command Mode

Configure VRF mode

Applicability

This command was introduced in OcNOS version 4.1.

Example

```
#configure terminal
(config)#ip vrf vrfip
(config-vrf)#l3vni 10002
(config-vrf)#no l3vni 10002
```

mac

Use this command to configure a static MAC address with IPv4/IPv6 address or only MAC address under the Access-Circuit.

Use the no form of this command to unconfigure a static MAC address with IPv4/IPv6 address and only MAC address from the Access-Circuit.

Note: Not applicable for the AC port which is mapped with ELINE Service.

For static mac addresses,

- 1) the local static is given preference over remote learned static.
- 2) if same static mac is configured on more than one interface of same VPN then conflict state need to be resolved manually by removing that static-mac on all access-interfaces where it was configured.

Command Syntax

```
mac XXXX.XXXX.XXXX [| ip A.B.C.D | ipv6 X:X::X:X)
no mac XXXX.XXXX.XXXX [| ip A.B.C.D | ipv6 X:X::X:X)
```

Parameters

XXXX.XXXX.XXXX	Static mac address
A.B.C.D	Static IPv4 address
X:X::X:X	Static IPv6 address

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 3.0.

Example

```
#configure terminal
(config)# interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#mac 0000.0000.1001
(config-access-if)#mac 0000.0000.1002 ip 10.10.10.1
(config-access-if)#mac 0000.0000.1003 ipv6 1201::1
(config-access-if)#end
```

evpn mpls mac-ageing-time

Use this command to set the dynamically learned MAC aging time.

Use the `no` form of this command to set the age out the MACs in hardware to its default (300 seconds).

Note: This command affects the default bridge ageing time.

Command Syntax

```
evpn mpls mac-ageing-time <10-572>
no evpn mpls mac-ageing-time
```

Parameters

<10-572>	Ageing time in seconds.
----------	-------------------------

Default

The default age out time is 300 seconds.

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#evpn mpls mac-ageing-time 10
```

evpn mpls multihoming enable

Use this command to enable evpn mpls multihoming

Use the `no` form of this command to disable evpn mpls multihoming.

Note: Node will have to be restarted for this to be applicable. If there are some nodes in topology which have multi-homed CEs, then the nodes which do not have multi-homed CEs should also enable multihoming, so that they can load share traffic to the multi-homed CEs.

Note: Before enabling multi-homing, configure the hardware-profiles with the [hardware-profile filter evpn-mpls-mh](#) commands.

Command Syntax

```
evpn mpls multihoming enable
no evpn mpls multihoming enable
```

Parameters

None

Default

By default evpn mpls multihoming is disabled.

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
#(config)# evpn mpls multihoming enable
#(config)# exit
```

evpn mpls vtep-ip-global

Use this command to set the source IP address is used to establish BGP peering with neighbor MPLS Nodes and to establish the EVPN MPLS tunnels.

Use the no version of this command to delete the source IP address.

Command Syntax

```
evpn mpls vtep-ip-global A.B.C.D
no evpn mpls vtep-ip-global A.B.C.D
```

Parameters

A.B.C.D IPv4 address type.

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
(config)#evpn mpls vtep-ip-global 10.10.11.1
(config)#no evpn mpls vtep-ip-global 10.10.11.1
```

evpn multi-homed

Use this command to configure interfaces as multi-homed and configure esi-value in case of physical and static lag and system-mac in case of Dynamic lag.

The command `evpn multi-homed` allows users to configure single-active and port-active load-balancing Ethernet Segment Identifier (ESI) on a link with a multihomed Customer Edge (CE).

Use the `no` parameter of this command to unconfigure multi-homed on the interface.

Command Syntax

```
evpn multi-homed esi XX:XX:XX:XX:XX:XX:XX:XX:XX (load-balancing (single-active)|)
evpn multi-homed system-mac (XX-XX-XX-XX-XX-XX|XX:XX:XX:XX:XX:XX|XXXX.XXXX.XXXX)
    (load-balancing (port-active)|)
no evpn multi-homed (esi | system-mac)
```

Parameters

XX:XX:XX:XX:XX:XX:XX:XX:XX	ESI value in HH:HH:HH:HH:HH:HH:HH:HH:HH - 9 octet format
XX-XX-XX-XX-XX-XX	Host MAC address (Option 1)
XX:XX:XX:XX:XX:XX	Host MAC address (Option 2)
XXXX.XXXX.XXXX	Host MAC address (Option 3)
port-active	To support ESI configuration for port-active redundancy mode.
single-active	To support ESI configuration for single-active redundancy mode.

Default

Default value is 0.

Command Mode

Interface Mode

Applicability

This command was introduced in OcNOS version 4.0 and underwent modifications in the OcNOS version 6.4.1 and OcNOS version 6.4.2.

Example

```
#configure terminal
(config)#interface xe1
(config)#evpn multi-homed esi 00:11:22:33:44:55:66:77:88 load-balancing single-
active
(config)#exit

configure terminal
(config)#interface po1
(config)#evpn multi-homed system-mac 0000.0000.1111 load-balancing port-active
(config)#exit
```

hardware-profile filter evpn-mpls-cw

This hardware filter needs to be enabled, to allow configuring EVPN-MPLS with control-word functionality per EVI. Filter cannot be disabled if "EVPN-MPLS" is globally enabled.

Before enabling EVPN MPLS per-evi control-word ([evpn mpls id](#) command), give this command.

Before disabling the hardware-profile, disable EVPN MPLS globally (no [evpn mpls enable](#)).

Note: You need to save the configuration and do a reboot after giving this command.

Use the disable form of this command to disable the configured hardware-profile.

Command Syntax

```
hardware-profile filter evpn-mpls-cw enable
hardware-profile filter evpn-mpls-cw disable
```

Parameters

None

Default

By default, EVPN MPLS control-word hardware-profile is disabled.

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 6.1.0.

Example

```
#configure terminal
(config)# hardware-profile filter evpn-mpls-cw enable
(config)# hardware-profile filter evpn-mpls-cw disable
```

hardware-profile filter evpn-mpls-mh

Use this command to enable the hardware-profile for EVPN MPLS multihoming to successfully activate multi-homing in the hardware.

Before enabling EVPN MPLS multihoming ([evpn mpls multihoming enable](#) command), give this command.

Before disabling the hardware-profile, disable EVPN MPLS multihoming.

Note: You need to save the configuration and do a reboot after giving this command.

Use the `disable` form of this command to disable the configured hardware-profile.

Command Syntax

```
hardware-profile filter evpn-mpls-mh enable
hardware-profile filter evpn-mpls-mh disable
```

Parameters

None

Default

By default, EVPN MPLS multihoming hardware-profile is disabled.

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)# hardware-profile filter evpn-mpls-mh enable
(config)# hardware-profile filter evpn-mpls-mh disable
```

hardware-profile statistics evpn-mpls

Use this command to enable or disable filter statistics in hardware for evpn mpls network counters.

Note: You need to save the configuration and do a reboot after giving this command.

Command Syntax

```
hardware-profile statistics evpn-mpls enable
hardware-profile statistics evpn-mpls disable
```

Parameters

None

Default

By default, evpn mpls statistics profile is disabled.

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 4.2.

Example

```
#configure terminal
(config)# hardware-profile statistics evpn-mpls enable
(config)# hardware-profile statistics evpn-mpls disable
```

host-reachability-protocol

Use this command to set the host reachable protocol to Ethernet-VPN over BGP. This defines BGP as the mechanism for host reachability advertisement to discover EVPN peers and to learn remote host details.

Use no form of this command to remove Ethernet-VPN as the host reachable protocol.

Command Syntax

```
host-reachability-protocol evpn-bgp WORD
no host-reachability-protocol evpn-bgp
```

Parameters

WORD MAC Routing/Forwarding instance name. Maximum limit 32 characters

Default

None

Command Mode

EVPN MPLS Config mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
(config)#evpn mpls id 1
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf1
```

ip address

Use this command to set anycast flag for primary and secondary subnets under IRB interface.

With this anycast gateway can be supported for multiple subnets.

Command Syntax

```
ip address [ <A.B.C.D/M> | anycast]
ip address [ <A.B.C.D> | <A.B.C.D> | anycast]
ip address [ <A.B.C.D/M> | secondary | anycast]
ip address [ <A.B.C.D> | <A.B.C.D> | secondary | anycast]
```

Default

The default value is router mac

Parameters

anycast	Anycast flag
secondary	Used for secondary address option

Command Mode

IRB_IF Mode

Applicability

The anycast flag was introduced in OcNOS version 6.3.0.

Example

```
(config)#interface irb2
(config-irb-if)#ip address 40.1.1.1/24 anycast
(config-irb-if)#ip address 41.1.1.1/24 secondary anycast
(config-irb-if)#
(config)#interface irb1
(config-irb-if)#ip address 42.1.1.1 255.255.255.0 anycast
(config-irb-if)#ip address 43.1.1.1 255.255.255.0 secondary anycast
(config-irb-if)#
```

ipv6 address

Use this command to set anycast flag for any configured subnets under IRB interface.

With this anycast gateway can be supported for multiple subnets.

Command Syntax

```
ipv6 address [ < X:X::X:X/M > | anycast]
```

Default

The default value is router mac

Parameters

anycast	Anycast flag
---------	--------------

Command Mode

IRB_IF Mode

Applicability

The anycast flag was introduced in OcNOS version 6.3.0.

Example

```
(config)#interface irb1
(config-irb-if)# ipv6 address 1100::1/64 anycast
```

mac-holdtime

Use this command to set the MAC hold time for a MAC/IP or MAC.

The feature holds the MAC in hardware until BGP has withdrawn from the neighbors. This helps to reduce the flooding to other access ports.

This setting applies when the L2 Subifp is shut down, the physical port on which the access port is down, or the access port is removed from the VNID using the no form of the map vnid command.

When the MAC hold time is configured as -1, then the MAC is not removed from the hardware and is also not withdrawn from EVPN BGP.

Use the no form of this command to remove the MAC hold time for the MAC/IP or MAC.

Note: When a MAC is moved to discard state, traffic to and from this MAC is discarded. This is applicable only on statically configured MAC/MAC-IPs.

Command Syntax

```
mac-holdtime <-1-300>
no mac-holdtime
```

Parameters

<-1-300> MAC hold time in seconds. Specify -1 to "never expire".

Default

The default holdtime for mac is 3 seconds.

Command Mode

EVPN MPLS mode and ACC_IF mode

Note: When configured in both modes, then the ACC_IF mode value takes preference for that access port.

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
#configure terminal
(config)#evpn mpls id 3
(config-evpn-mpls)#mac-holdtime -1
(config-evpn-mpls)#exit
```

mac-vrf

Use this command to create a MAC VRF to use in EVPN routes.

Use the `no` form of this command to delete the MAC VRF.

Command Syntax

```
mac vrf WORD
no mac vrf WORD
```

Parameters

`WORD` `MAC` Routing/Forwarding instance name. Maximum limit 32 characters

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
#configure terminal
(config)#mac vrf vrf1
(config)#no mac vrf vrf1
```

map vpn-id

Use this command to map a sub-interface to a tenant.

Use the no form of this command to remove the tenant.

Command Syntax

```
map vpn-id <1-16777215>
no map vpn-id <1-16777215>
```

Parameters

<1-16777215> VNID

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#map vpn-id 1
(config-access-if)#end
```

nd-cache disable

Use this command to disable ND cache for MAC/IPv6.

When the ND cache is disabled on an Access Circuits, It does not reply to any ND arriving on this port from the cache. It withdraws all MAC/IPs configured/learned on this Access Circuit and removes the MAC/IP entry for this AC from the local ND cache.

It also makes sure that on withdrawing the MAC/IP route, the MAC does not become unknown. If all routes for this MAC are being withdrawn because of this command, then it advertises a MAC-only route. This is done so that the MAC does not become unknown and only the cache functionality becomes disabled.

Use the `no` form of this command to enable ND cache for MAC/IPv6.

Note: On enabling the cache, an IP will be in conflict, then the cache enable will fail. The conflict has to be manually removed and then the cache enabled.

Note: Not applicable for the AC port which is mapped with ELINE/Xconnect Service.

Command Syntax

```
nd-cache disable
no nd-cache disable
```

Parameters

None

Default

By default, the nd-cache option is enabled.

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#nd-cache disable
(config-access-if)#end
```

show bgp l2vpn evpn

Use this command to display details about Layer 2 Virtual Private Network (L2VPN) Ethernet Virtual Private Network (EVPN) routes.

Note: A BGP EVPN route update received for an unreachable IP address is also listed by this command and as a best route. This is because the next hop tracking feature is not supported for the EVPN address family. However, the tunnel to this IP address is shown in unresolved state by the show nvo vxlan tunnel output.

Note: An E-tag (Ethernet tag) can have the value of zero/VID/VNID based on the use case. An E-tag can go up to 32 bits and no restrictions are noted in the RFC. Since an E-tag can have different values, it should not be compared with the label/VNID.

Command Syntax

```
show bgp l2vpn evpn ((vrf WORD)|(rd WORD)| time|)
show bgp l2vpn evpn mac-ip ((vrf WORD)|(rd WORD)|)
show bgp l2vpn evpn mcast
show bgp l2vpn evpn multihoming es-route <(rd WORD)|(vrf WORD)>
show bgp l2vpn evpn multihoming ethernet-ad-per-evi <(rd WORD)|(vrf WORD)>
show bgp l2vpn evpn multihoming ethernet-ad-per-es <(rd WORD)|(vrf WORD)>
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
MH-PE2#sh bgp l2vpn evpn
BGP table version is 22, local router ID is 102.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal,
                l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

      Network      Next Hop      Metric      LocPrf      Weight
Path  Peer        Encap
RD[101.1.1.1:1]
*>i  [1]:[00:00:00:00:00:15:15:00:00:00]:[6001]:[18]
```

```

101.1.1.1          101.1.1.1          0          100          0          i
101.1.1.1          MPLS
*>i   [3]:[6001]:[32,101.1.1.1]
101.1.1.1          101.1.1.1          0          100          0          i
101.1.1.1          MPLS

RD[101.1.1.1:2]
*>i   [1]:[00:00:00:00:00:15:15:00:00:00]:[10]:[19]
101.1.1.1          101.1.1.1          0          100          0          i
101.1.1.1          MPLS

RD[101.1.1.1:22]
*>i   [1]:[00:00:00:00:00:15:15:00:00:00]:[4294967295]:[0]
101.1.1.1          101.1.1.1          0          100          0          i
101.1.1.1          MPLS
*>i   [4]:[00:00:00:00:00:15:15:00:00:00]:[32,101.1.1.1]
101.1.1.1          101.1.1.1          0          100          0          i
101.1.1.1          MPLS

RD[102.1.1.1:1] VRF[l2vrf1]:
*>   [1]:[00:00:00:00:00:15:15:00:00:00]:[6001]:[19]
-----          102.1.1.1          0          100          32768          i
-----          MPLS
* i   101.1.1.1          101.1.1.1          0          100          0          i
101.1.1.1          MPLS
* i   [1]:[00:00:00:00:00:15:15:00:00:00]:[4294967295]:[0]
101.1.1.1          101.1.1.1          0          100          0          i
101.1.1.1          MPLS
*>   [2]:[00:00:00:00:00:15:15:00:00:00]:[6001]:[48,0000:0000:aa11]:[0]:[19]
102.1.1.1          102.1.1.1          0          100          32768          i
-----          MPLS
*>
[2]:[00:00:00:00:00:15:15:00:00:00]:[6001]:[48,0000:0000:aa12]:[32,12.12.12.10]:[19]
-----          102.1.1.1          0          100          32768          i
-----          MPLS
*>
[2]:[00:00:00:00:00:15:15:00:00:00]:[6001]:[48,0000:0000:aa13]:[128,1201::10]:[19]
-----          102.1.1.1          0          100          32768          i
-----          MPLS
* i   [3]:[6001]:[32,101.1.1.1]
101.1.1.1          101.1.1.1          0          100          0          i
101.1.1.1          MPLS
*>   [3]:[6001]:[32,102.1.1.1]
102.1.1.1          102.1.1.1          0          100          32768          i
-----          MPLS
* i   [3]:[6001]:[32,105.1.1.1]
105.1.1.1          105.1.1.1          0          100          0          i
105.1.1.1          MPLS

RD[102.1.1.1:2] VRF[l2vrf2]:
* i   [1]:[0]:[11]:[641]
105.1.1.1          105.1.1.1          0          100          0          i
105.1.1.1          MPLS
*>   [1]:[00:00:00:00:00:15:15:00:00:00]:[10]:[18]
102.1.1.1          102.1.1.1          0          100          32768          i
-----          MPLS
* i   101.1.1.1          101.1.1.1          0          100          0          i
101.1.1.1          MPLS

```

```

* i  [1]:[00:00:00:00:00:15:15:00:00:00]:[4294967295]:[0]
101.1.1.1      MPLS      101.1.1.1      0      100      0      i

RD[102.1.1.1:22] VRF[evpn-gvrf-1]:
*>  [1]:[00:00:00:00:00:15:15:00:00:00]:[4294967295]:[0]
-----      MPLS      102.1.1.1      0      100      32768      i
* i  [4]:[00:00:00:00:00:15:15:00:00:00]:[32,101.1.1.1]
101.1.1.1      MPLS      101.1.1.1      0      100      0      i
101.1.1.1      MPLS
*>  [4]:[00:00:00:00:00:15:15:00:00:00]:[32,102.1.1.1]
-----      MPLS      102.1.1.1      0      100      32768      i

RD[105.1.1.1:1]
*>i  [3]:[6001]:[32,105.1.1.1]
105.1.1.1      MPLS      105.1.1.1      0      100      0      i

RD[105.1.1.1:2]
*>i  [1]:[0]:[11]:[641]
105.1.1.1      MPLS      105.1.1.1      0      100      0      i

Total number of prefixes 21
MH-PE2#
MH-PE2#

```


show evpn load-balance

Use this command to display ESI information in Single-Active or Port-Active mode. It assists the user in identifying whether the local device is in Active or Standby mode and understanding which election algorithm is used for ESI. In remote devices, information will only be displayed for ELINE services.

This command is used to debug and understand if the election process is occurring correctly. The commands on multi-homed devices are symmetric, and they provide insights into the election algorithm used for the DF election.

Command Syntax

```
show evpn load-balance (port-active | single-active | all)
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 6.4.1 and underwent modifications in the OcNOS version 6.4.2

Example

The following example displays ESI information using the `show evpn load-balance port-active` and `show evpn load-balance single-active` commands.

```
OcNOS#show evpn load-balance port-active
ESI                               AC-IF/PE  PE-IP-ADDRESS  Redundancy  Service-carving  weight  Revertive  AC-DF  Status
=====
00:00:00:00:00:12:12:00:00:00  REMOTE   101.1.1.1      port-active  auto             0       NO         NA     ACTIVE
00:00:00:00:00:12:12:00:00:00  LOCAL    102.1.1.1      port-active  auto             0       NO         NA     STANDBY

#show evpn load-balance single-active
ESI                               AC-IF/PE  PE-IP-ADDRESS  Redundancy  Service-carving  weight  Revertive  AC-DF  Status
=====
00:11:22:33:00:00:00:55:66:77  sal.1    1.2.3.4        single-active  preference-based  200     NO         NO     ACTIVE
00:11:22:33:00:00:00:55:66:77  ----    3.4.5.6        single-active  preference-based  100     NO         NO     ----
```

Table 4-13 explains the output fields.

Table 4-13: show evpn load-balance port-active

Field	Description
ESI	Ethernet Segment Identifier, a unique identifier for an Ethernet Segment.
AC-IF/PE	This field indicates whether the ESI is associated with a local or remote Attachment Circuit (AC) or Provider Edge (PE).
PE-IP-ADDRESS	The IP address of the PE associated with the ESI.
Redundancy	Indicates whether the ESI is configured for port-active or single-active redundancy.
Service-carving	The service carving mode associated with the ESI.
weight	Weight assigned to the ESI.

Table 4-13: show evpn load-balance port-active

Field	Description
Revertive	Indicates whether the ESI is configured for revertive mode.
AC-DF	Attachment Circuit Designated Forwarder status.
Status	The status of the ESI, whether it's active or standby.

show evpn mpls

Use this command to display the EVPN Information.

Command Syntax

```
show evpn mpls (|id <1-16777215>)
```

Parameters

<1-16777215> EVPN-MPLS tenant identifier

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Example

```
MH-PE2#sh evpn mpls
EVPN-MPLS Information
=====
```

```
Codes: NW - Network Port
       AC - Access Port
       (u) - Untagged
```

VPN-ID	EVI-Name	EVI-Type	Type	Interface	ESI	VLAN	DF-Status	Src-Addr	Dst-Addr
6001	----	L2	NW	----	----	----	----	102.1.1.1	101.1.1.1
6001	----	L2	NW	----	----	----	----	102.1.1.1	105.1.1.1
6001	----	--	AC	xe1.301	--- Single Homed Port ---	----	----	----	----
6001	----	--	AC	po10.301	00:00:00:00:00:15:15:00:00:00	----	DF	----	----
6002	----	L2	NW	----	----	----	----	102.1.1.1	101.1.1.1
6002	----	L2	NW	----	----	----	----	102.1.1.1	105.1.1.1
6002	----	--	AC	po10.302	00:00:00:00:00:15:15:00:00:00	----	NON-DF	----	----

```
Total number of entries are 7
MH-PE2#
```

show evpn mpls arp-cache

Use this command to display the ARP cache information.

Command syntax

```
show evpn mpls arp-cache (|evid <1-16777215>) summary
```

Parameters

evid	EVPN-MPLS tenant identifier
<1-16777215>	Range supported for EVID
summary	Ethernet Virtual Private Network ID

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
PE1#show evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
=====
EVPN-ID    Ip-Addr          Mac-Addr          Type             Age-Out    Retries-Left
-----
2001       122.122.122.1    0000.0000.1111    Dynamic Local    ----
2001       122.122.122.2    0000.0000.2222    Dynamic Remote   ----
Total number of entries are 2
PE1#
```

show evpn mpls counters

This command to display the ingress/egress evpn-mpls network port statistic counters for both BUM and known unicast data traffic.

Note: To see the statistics, you must enable the command `hardware-profile statistics evpn-mpls enable` and reboot the board for the command to take effect.

Command syntax

```
show evpn mpls counters ((network (ingress|(egress dst <A.B.C.D>)))| vpn-id <1-16777215> (network (ingress|(egress dst <A.B.C.D>))))
```

Parameters

<1-16777215> VPN identifier
A.B.C.D Ipv4 address

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
DUT2#show evpn mpls counters network egress
```

VPN-ID	DESTINATION PEER	BUM TX (pkts)	Unicast TX (pkts)
2000	2.2.2.2	140136	68900
1999	2.2.2.2	140138	68899
1998	2.2.2.2	140136	68899
1997	2.2.2.2	140137	68897

```
DUT2#
```

```
DUT2#show evpn mpls counters network ingress
```

VPN-ID	BUM RX (pkts)	Unicast RX (pkts)
30	0	800122
10	0	727383
4001	5	727362
3003	0	0
3002	727368	0
3001	3	727364

```
DUT2#
```

show evpn mpls label alias

Use this command to display the alias label details of the MH Nodes.

Command syntax

```
show evpn mpls label alias
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
Remote-PE3#sh evpn mpls label alias
```

```
S - Self
```

```
R - Remote
```

ESI	PE-IP-ADDRESS	TENANT	ALIAS-LABEL
00:00:00:00:00:15:15:00:00:00	101.1.1.1 (R)	6001	18
00:00:00:00:00:15:15:00:00:00	101.1.1.1 (R)	6002	20
00:00:00:00:00:15:15:00:00:00	101.1.1.1 (R)	11	19
00:00:00:00:00:15:15:00:00:00	102.1.1.1 (R)	6001	19
00:00:00:00:00:15:15:00:00:00	102.1.1.1 (R)	6002	20
00:00:00:00:00:15:15:00:00:00	102.1.1.1 (R)	11	18

```
Remote-PE3#  
Remote-PE3#
```

show evpn mpls label esi

Use this command to display the esi label details of MH Nodes.

Command syntax

```
show evpn mpls label esi
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
MH-PE1#sh evpn mpls label esi
```

```
S - Self
```

```
R - Remote
```

ESI	PE-IP-ADDRESS	ESI-LABEL
=====		
00:00:00:00:00:13:13:00:00:00	101.1.1.1 (S)	38
00:00:00:00:00:13:13:00:00:00	102.1.1.1 (R)	43
00:00:00:00:00:15:15:00:00:00	101.1.1.1 (S)	37
00:00:00:00:00:15:15:00:00:00	102.1.1.1 (R)	42

show evpn mpls mac-table

Use this command to display the host MAC address table.

Command Syntax

```
show evpn mpls mac-table (|evid <1-16777215>|) (summary | hardware |)
```

Parameters

<1-16777215> EVPN-MPLS tenant identifier

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Example

```
PE1#sh evpn mpls mac-table
=====
EVPN MPLS MAC Entries
=====
VNID      Interface VlanId Inner-VlanId Mac-Addr      VTEP-Ip/ESI      Type      Status      Time-
out AccessPortDesc
-----
2001      ----      ----      ----      0000.0000.aa21  101.1.1.1      Dynamic Remote      -----      -
-----
2001      xe1.14      ----      ----      0000.0000.bb21  105.1.1.1      Dynamic Local      -----      -
-----
1001      ----      ----      ----      0000.0000.aa11  101.1.1.1      Dynamic Remote      -----      -
-----
1001      xe1.2      ----      ----      0000.0000.bb11  105.1.1.1      Static Local      -----      -
-----

Total number of entries are : 4

PE1#
```


show evpn mpls nd-cache

Use this command to display the ND cache information.

Command Syntax

```
show evpn mpls nd-cache (|evid <1-16777215>) summary
```

Parameters

evid	EVID
<1-16777215>	Range supported for EVID
summary	Ethernet Virtual Private Network ID

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
PE1#
PE1#show evpn mpls nd-cache
MPLS-EVPN ND-CACHE Information
=====
EVPN-ID  Ip-Addr                Mac-Addr                Type                Age-Out
Retries-Left
-----
1001      1201::1                      0000.0000.cc10 Dynamic Local      ----
1001      1201::2                      0000.0000.dd10 Dynamic Remote     ----
Total number of entries are 2
PE1#
PE1#
```

show evpn mpls route-count

Use this command to display the evpn active route (MAC-IP.MAC-IPv6 and MAC-only) count information.

Command Syntax

```
show evpn mpls route-count (|evid <1-16777215>)
```

Parameters

evid EVPN-MPLS tenant identifier

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
PE1#show evpn mpls route-count
EVPN-MPLS Active route count information
=====
Max route count      : 32768
Active route count: 6
```

VNID	Total	MACONLY	MACIPv4	MACIPv6
6001	3	1	1	1
7001	3	1	1	1

```
Total number of entries are 2
PE1#
```

Table 4-14 explains the output fields.

Table 4-14: show evpn mpls route-count fields

Field	Description
Max route count	Maximum number of route count in evpn mpls.
Active route count	Number of active route count in the interface.
VNID	VNID is used to identify Layer 2 segments and to maintain Layer 2 isolation between the segments.
Total	Total number of entries for the interface.
MACONLY	The MAC-only route for both the local and the remote entries in the EVPN MPLS instance route table.

Table 4-14: show evpn mpls route-count fields

Field	Description
MACIPv4	IPv4 media access control (MAC) address for a default virtual gateway.
MACIPv6	IPv6 media access control (MAC) address for a default virtual gateway.

show evpn mpls static host state

Use this command to display the state of the host which is configured statically.

Command Syntax

```
show evpn mpls static host state
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
MH-PE2#sh evpn mpls static host status
```

```
MPLS Static Host Information
```

```
=====
```

```
Codes: NW - Network Port
```

```
AC - Access Port
```

```
(u) - Untagged
```

VNID	Ifname	Outer-Vlan	Inner-vlan	Ip-Addr	Mac-Addr	Status
6001	po10.301	---	---	0.0.0.0	0000.0000.aa11	Active
6001	po10.301	---	---	12.12.12.10	0000.0000.aa12	Active
6001	po10.301	---	---	1201::10	0000.0000.aa13	Active

```
Total number of entries are 3
```

```
MH-PE2#
```

show evpn mpls status

Use this command to display EVPN MPLS status in hardware.

Command Syntax

```
show evpn mpls status
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Example

```
PE-1#show evpn mpls status
EVPN-MPLS is ACTIVE in Hardware
```

show evpn mpls tunnel

Use this command to view the active EVPN MPLS tunnels for ELAN.

Command Syntax

```
show evpn mpls tunnel [| summary]
```

Parameters

summary	Summary information
---------	---------------------

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Example

```
PE1#sh evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status          Up/Down         Update          evpn-id
=====
101.1.1.1        105.1.1.1       Installed       00:43:09       00:43:09       2001
101.1.1.1        105.1.1.1       Installed       00:43:09       00:43:09       1001

Total number of entries are 2
PE1#
```

show evpn mpls tunnel label

Use this command to display the label details of the EVPN tunnels.

Command Syntax

```
show evpn mpls tunnel label
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0 and RSVP multipath was introduced in OcNOS version 5.0.

Example

```
PE1#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
(*) in Policy - tunnel-policy inherited from mac-vrf
=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====
=====+=====
Destination      Status      VPN-ID      Policy      Local      Remote      RSVP-Multipath      Underlay
NW-Label      MC-Label  UC-Label  MC-Label  UC-Label  Grp-Name  NHLFE-ix  NW-Intf
=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====
3.3.3.3         Installed    601         --          640        17          640        17          --          --          xe10
24320
3.3.3.3         Installed    801         --          641        18          641        18          --          --          xe10
24320
4.4.4.4         Installed    1601        --          642        20          640        17          MP1         12          NA          NA
4.4.4.4         Installed    1801        --          643        21          641        18          MP1         12          NA          NA

Total number of entries are 4
PE1#
```

show evpn mpls xconnect

Use this command to display the VPWS xconnect details of the MTU, AC-NW connections, and network status.

Command Syntax

```
show evpn mpls xconnect
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
Remote-PE3#sh evpn mpls xconnect
```

```
EVPN-MPLS Xconnect Info
```

```
=====
```

```
AC-AC: Local-Cross-connect
```

```
AC-NW: Cross-connect to Network
```

```
AC-UP: Access-port is up
```

```
AC-DN: Access-port is down
```

```
NW-UP: Network is up
```

```
NW-DN: Network is down
```

```
NW-SET: Network and AC both are up
```

Local			Remote		Connection-Details				
=====			=====		=====				
VPN-ID	EVI-Name	MTU	VPN-ID	Source	Destination	PE-IP	MTU	Type	NW-Status
=====			=====		=====				
11	----	1500	10	xe1.10	00:00:00:00:00:15:15:00:00:00	102.1.1.1	1500	AC-NW	NW-SET
						101.1.1.1	1500	----	----
40	----	1500	30	xe2.2	--- Single Homed Port ---	102.1.1.1	1500	AC-NW	NW-SET

```
Total number of entries are 2
```

```
Remote-PE3#
```

show evpn mpls xconnect tunnel

Use this command to view the active EVPN MPLS Tunnels for ELINE.

Command Syntax

```
show evpn mpls xconnect tunnel [| summary]
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
PE1#
PE1#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source          Destination      Status      Up/Down      Update      local-evpn-id remote-evpn-id
=====
101.1.1.1       105.1.1.1       Installed   01:25:48     01:25:48     50           60
101.1.1.1       105.1.1.1       Installed   00:07:53     00:07:53     30           40
101.1.1.1       105.1.1.1       Installed   00:07:55     00:07:55     10           20

Total number of entries are 3
PE1#
```

show evpn mpls xconnect tunnel label

Use this command to display the label details of EVPN tunnels for ELINE.

Command Syntax

```
show evpn mpls xconnect tunnel label
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0 and RSVP-Multipath is introduced in OcNOS version 5.0.

Example

```
PE1#
PE1#show evpn mpls xco tunnel label
EVPN-MPLS Network tunnel labels
(*) in Policy - tunnel-policy inherited from mac-vrf
=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====
=====
Destination      Status      Local      Remote      Policy      Local      Remote      RSVP-Multipath      Underlay
=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====
UC-Label  UC-Label  Grp-Name      NHLFE-ix  NW-Intf      NW-Label
=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====+=====
3.3.3.3        Installed    501         1           --           16         16         MP2                10         NA           NA
4.4.4.4        Installed    1501        1001        --           19         16         --                 --         xe10         24320

Total number of entries are 2
PE1#
```

show running-config evpn mpls

Use this command to display the current running configuration of EVPN MPLS.

Command Syntax

```
show running-config evpn mpls
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#show running-config evpn mpls
!
evpn mpls enable
!
evpn mpls vtep-ip-global 101.1.1.1
!
evpn mpls multihoming enable
!
evpn esi hold-time 30
!
evpn mpls mac-ageing-time 180
!
evpn mpls arp-nd refresh-timer 60
!
evpn mpls id 10 xconnect target-mpls-id 20
  host-reachability-protocol evpn-bgp l2vrf5
!
vpn-id 1001
  host-reachability-protocol evpn-bgp l2vrf1
  mac-holdtime 300
  evi-name ELANE
!
interface xel.2 switchport
  access-if-evpn
  map vpn-id 1001
  dynamic-learning disable
  arp-nd flood-suppress
  mac-holdtime 200
  arp-cache disable
  nd-cache disable
  mac 0000.0000.aa31
  mac 0000.0000.aa32 ip 12.12.12.10
  mac 0000.0000.aa33 ipv6 1201::1
!
interface xel.10 switchport
```

```
encapsulation dot1q 10
access-if-evpn
  map vpn-id 10
!
```

tunnel-select-policy

Use this command to associate tunnel-policy to an EVPN instance and to a mac-vrf. This will be used while selecting transport for EVPN service. In particular, an EVPN instance could be either an ELINE or ELAN type and may also multi-homing also enabled.

Use the `no` parameter with this command to un-configure tunnel-policy from the EVPN instance.

Please refer [MPLS Service Mapping Configuration](#) for Tunnel-policy Name configuration.

Command Syntax

```
tunnel-select-policy NAME
no tunnel-select-policy
```

Parameters

NAME	Name of tunnel-policy
------	-----------------------

Command Mode

EVPN MPLS Config mode and MAC_VRF MODE

Note:

Applicability

This command was introduced in OcNOS version 4.1 but the support for this CLI under mac-vrf mode is introduced in OcNOS-SP version 4.2.

Examples

```
#configure terminal
(config)#mac vrf vrf1
(config-vrf)# tunnel-select-policy policy1
(config-vrf)#end
(config)# evpn mpls id 1001
(config-evpn-mpls)# tunnel-select-policy policy2
(config-evpn-mpls)# end
(config)# evpn mpls id 10 xconnect target-mpls-id 20
(config-evpn-mpls)# tunnel-select-policy policy3
(config-evpn-mpls)# end
```

CHAPTER 5 MPLS Service Mapping Commands

This chapter describes each MPLS Service Mapping command.

- [color](#)
- [mode](#)
- [mpls 6pe tunnel-select-policy](#)
- [show running-config tunnel-policy](#)
- [show tunnel-policy](#)
- [tunnel-policy](#)
- [tunnel-select-policy \(For L3VPN service\)](#)

color

Use this command to set color value for a tunnel policy. This value will be used while selecting transport for given service.

Use the `no` parameter with this command to un-configure color value for tunnel policy.

Command Syntax

```
color <1-4294967295>
no color <1-4294967295>
```

Parameters

color	Configure color code
-------	----------------------

Command Mode

Tunnel policy mode

Applicability

This command was introduced in OcNOS version 4.2.

Example

```
#configure terminal
(config)#tunnel-policy policy1
(config-tnl-policy)#color 23
```

mode

Use this command to set tunnel selection mode for a tunnel policy. This will be used while selecting transport for given service. Mode can be dedicated or best-effort.

Use the `no` parameter with this command to set mode to default mode.

Command Syntax

```
mode dedicated|best-effort
no mode
```

Parameters

<code>best-effort</code>	Best effort tunnel selection mode
<code>dedicated</code>	Dedicated tunnel selection mode (Default)

Default

Dedicated

Command Mode

Tunnel policy mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#configure terminal
(config)#tunnel-policy policy1
(config-tnl-policy)# mode best-effort
```

mpls 6pe tunnel-select-policy

Use this command to set tunnel-policy for a 6PE services. This will be used while selecting transport for 6PE services. Use the `no` parameter with this command to unconfigure tunnel selection policy for 6PE.

Command Syntax

```
mpls 6pe tunnel-select-policy NAME
```

Parameters

NAME	Name of tunnel-policy
------	-----------------------

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#configure terminal
(config)# mpls 6pe tunnel-select-policy policy1
```

show running-config tunnel-policy

Use this command to display the current running configuration of all tunnel policies.

Command Syntax

```
show running-config tunnel-policy
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#show running-config tunnel-policy
!
tunnel-policy tp1
  color 1
!
```

show tunnel-policy

Use this command to display the tunnel policy details.

Command Syntax

```
show tunnel-policy (NAME (service (((6pe|vpls|vpws|evpn|l3vpn|) details)) |
(count)))| service details |)
```

Parameters

NAME	show tunnel policy table by name
service	show service information
6pe	Display 6PE service details
evpn	Display EVPN service details
l3vpn	Display L3VPN service details
vpls	Display VPLS service details
vpws	Display VPWS service details
count	show counts
details	show details
service	show service information
details	show details

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

The following sample shows the summary of all configured tunnel policies.

```
#show tunnel-policy
tunnel-policy tp1
  color 1
  tunnel-mode dedicated
  tunnel-type any
Total Services attached:
VRF      : 1
VPWS     : 1
VPLS     : 1
EVPN     :
```

The following sample shows the summary of specific configured tunnel policy by name.

```
#show tunnel-policy tp1
tunnel-policy tp1
```

```

    color 1
    tunnel-mode dedicated
    tunnel-type any
Total Services attached:
  VRF      : 1
  VPWS     : 1
  VPLS     : 1
  EVPN     : 0

```

The following sample shows the detailed information of all the configured tunnel policies.

```

#show tunnel-policy service details
List of services configured with tunnel-policy tp1:
  VPWS
    VPWS-Id: 100, Name: vpws1 Status: UP, Mapped Tunnel: RSVP, ftn_ix 4, color
1
  L3VPN
    VRF id 2
      FTN id: 1, Prefix: 20.10.30.0/24, Status: Up, Label: 25664, Mapped Tunnel:
RSVP, ftn_ix 4, color 1
      FTN id: 2, Prefix: 3001::/64, Status: Up, Label: 25664, Mapped Tunnel:
RSVP, ftn_ix 4, color 1
    VPLS
      VPLS-Id: 300, Name: vpls1, Status: UP, Mapped Tunnel: RSVP, ftn_ix 4, color
1

```

The following sample shows the detailed information of specific configured tunnel policy by name.

```

# show tunnel-policy tp1 service details
Total services using tunnel-policy tp1:
  VPWS
    VPWS-Id: 100, Name: vpws1 Status: UP, Mapped Tunnel: RSVP, ftn_ix 4, color
1
  L3VPN
    VRF id 2
      FTN id: 1, Prefix: 20.10.30.0/24, Status: Up, Label: 25664, Mapped Tunnel:
RSVP, ftn_ix 4, color 1
      FTN id: 2, Prefix: 3001::/64, Status: Up, Label: 25664, Mapped Tunnel:
RSVP, ftn_ix 4, color 1
    VPLS
      VPLS-Id: 300, Name: vpls1, Status: UP, Mapped Tunnel: RSVP, ftn_ix 4, color
1

```

The following sample shows the services count of specific tunnel policy by name.

```

#show tunnel-policy tp1 service count
Total services using tunnel-policy tp1:
  VPWS      : 1
  VPLS      : 0
  L3VPN     : 2
  6PE       : 0
  EVPN      : 0

```

The following sample shows the detailed VPLS service information of specific tunnel policy by name.

```

#show tunnel-policy tp1 service vpls details
Total services using tunnel-policy tp1:
  VPLS

```

```

1 VPLS-Id: 300, Name: vpls1, Status: UP, Mapped Tunnel: RSVP, ftn_ix 4, color

```

The following sample shows the detailed VPWS service information of specific tunnel policy by name.

```

#show tunnel-policy tp1 service vpws details
Total services using tunnel-policy tp1:
  VPWS
1  VPWS-Id: 100, Name: vpws1 Status: UP, Mapped Tunnel: RSVP, ftn_ix 4, color

```

The following sample shows the detailed L3VPN service information of specific tunnel policy by name.

```

#show tunnel-policy tp1 service l3vpn details
Total services using tunnel-policy tp1:
  L3VPN
    VRF id 2
      FTN id: 1, Prefix: 20.10.30.0/24, Status: Up, Label: 25664, Mapped Tunnel:
RSVP, ftn_ix 4, color 1
      FTN id: 2, Prefix: 3001::/64, Status: Up, Label: 25664, Mapped Tunnel:
RSVP, ftn_ix 4, color 1

```

The following sample shows the detailed 6PE service information of specific tunnel policy by name.

```

#show tunnel-policy tp1 service 6pe details
Total services using tunnel-policy tp1:
  6PE
    FTN id: 3, Prefix: 3002::/64, Status: Up, Label: 25665, Mapped Tunnel:
RSVP, ftn_ix 4, color 1

```

The following sample shows the detailed EVPN service information of specific tunnel policy by name.

```

#show tunnel-policy tp1 service evpn details
Total services using tunnel-policy tp1:
  EVPN
    EVPN-Id: 30, Tunnel count: 1
    Peer: 105.1.1.1, Mapped Tunnel: SR_POLICY, ftn_ix 3, color 202
    EVPN-Id: 1001, Tunnel count: 2
    Peer: 105.1.1.1, Mapped Tunnel: SR_POLICY, ftn_ix 3, color 202    Peer:
101.1.1.1, Mapped Tunnel: SR_POLICY, ftn_ix 4, color 204

```

tunnel-policy

Use this command to create a tunnel policy.

Use the `no` parameter with this command to un-configure the tunnel policy. Tunnel policy can be un-configured only if no service is using it.

Command Syntax

```
tunnel-policy NAME
no tunnel-policy NAME
```

Parameters

NAME	Name to be used for tunnel policy
------	-----------------------------------

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 4.2.

Example

```
#configure terminal
(config)#tunnel-policy policy1
```

tunnel-select-policy (For L3VPN service)

Use this command to set tunnel-policy for a VRF instance. This will be used while selecting transport for L3VPN service.

Use the `no` parameter with this command to un-configure tunnel-policy from VRF instance.

Command Syntax

```
tunnel-select-policy NAME
no tunnel-select-policy
```

Parameters

NAME	Name of tunnel-policy
------	-----------------------

Command Mode

IP VRF mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#configure terminal
(config)#ip vrf vrf1
(config-vrf)#tunnel-select-policy policy1
```

CHAPTER 6 MPLS LSP BFD Commands

This chapter describes each ICCP (Inter-Chassis Communication Protocol) command.

- [lsp ping-interval](#)
- [min-tx](#)
- [mpls bfd](#)
- [shutdown](#)

lsp ping-interval

Use this command to configure periodic MPLS ping echo request for BFD session over MPLS LSP.

Use **no** form of the command to set default periodic MPLS ping echo request interval.

Command Syntax

```
lsp-ping-interval <0-1000>
no lsp-ping-interval
```

Parameters

<0-1000>	Ping interval in sec
----------	----------------------

Command Mode

MPLS BFD mode.

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#configure terminal
(config)# mpls bfd ldp all
(config-mpls-bfd)# lsp-ping-interval 10
```

min-tx

Use this command to configure BFD transmit and receive intervals, and the hello multiplier value for MPLS LSP BFD session.

Use the `no` form of the command to set the intervals and multiplier to their default values.

Command Syntax

```
min-tx <50-999> min-rx <50-999> multiplier <3-50>
no min-tx <50-999> min-rx <50-999> multiplier <3-50>
```

Parameters

<code>min-tx</code>	Set BFD Min Tx interval
<code><50-999></code>	Desired Tx interval in ms.
<code>min-rx</code>	Set BFD Min Rx interval
<code><50-999></code>	Desired Rx interval in ms.
<code>Multiplier</code>	Set BFD Detection Multiplier
<code><3-50></code>	Multiplier value

Defaults

The default for the transmit and receive intervals is 10 milliseconds. The default hello multiplier value is 3.

Command Mode

MPLS BFD mode.

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#configure terminal
(config)# mpls bfd ldp all
(config-mpls-bfd)# min-tx 10 min-rx 10 multiplier 3
```

mpls bfd

Use this command to configure BFD session for MPLS LSP.

Use `no` form of the command to unconfigure BFD session from MPLS LSP.

Command Syntax

```
mpls bfd ((ldp A.B.C.D/M)|(rsvp tunnel-name NAME)|(static A.B.C.D/M))
mpls bfd (ldp|rsvp|static) all
no mpls bfd ((ldp A.B.C.D/M)|(rsvp tunnel-name NAME)|(static A.B.C.D/M))
no mpls bfd (ldp|rsvp|static) all
```

Parameters

<code>ldp</code>	LDP type LSP
<code>A.B.C.D/M</code>	LDP FEC
<code>all</code>	All LSPs
<code>rsvp</code>	RSVP type LSP
<code>tunnel-name</code>	RSVP Tunnel
<code>all</code>	All LSPs
<code>static</code>	Static type LSP
<code>A.B.C.D/M</code>	Static FEC
<code>all</code>	All LSPs

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#configure terminal
(config)# mpls bfd ldp all
(config-mpls-bfd)#
```

shutdown

Use this command to configure MPLS LSP BFD session in Admin Down state or to disable BFD session.

Use `no` form of the CLI to enable BFD session.

Command Syntax

```
shutdown
no shutdown
```

Parameters

None

Command Mode

MPLS BFD mode.

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#configure terminal
(config)# mpls bfd ldp all
(config-mpls-bfd)# shutdown
```

CHAPTER 7 L2VPN over L2 Subinterface Commands

This chapter is a reference for the L2VPN commands over L2 subinterface.

VPWS:

- [access-if-vpws](#)
- [mpls-l2-circuit](#)
- [vc-mode](#)

VPLS:

- [access-if-vpls](#)
- [mpls-vpls](#)
- [learning disable](#)
- [split-horizon \(subinterface\)](#)
- [static-mac](#)

access-if-vpws

Use this command in L2 subinterface mode to create the vpws access-port.

Use the `no` form of this command to delete the vpws access port.

Command Syntax

```
access-if-vpws
no access-if-vpws
```

Parameters

None

Command Mode

L2 Sub-interface mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-vpws
(config-acc-if-vpws)#end
```

mpls-l2-circuit

Use this command to bind an mpls-l2-circuit to an L2 subinterface

Use the `no` form of this command to unbind an mpls-l2-circuit from an L2 subinterface

Command Syntax

```
mpls-l2-circuit NAME (primary | secondary)
no mpls-l2-circuit NAME
```

Parameters

NAME	A string identifying the MPLS Layer-2 Virtual Circuit
primary	Identify L2 circuit as the primary link
secondary	Identify L2 circuit as the secondary link; the secondary link is not activated unless the primary link fails

Command Mode

access-if-vpws mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-vpws
(config-acc-if-vpws)#mpls-l2-circuit vc1 primary
(config-acc-if-vpws)#mpls-l2-circuit vc2 secondary
(config-acc-if-vpws)#end
```

vc-mode

Use this command to configure vc-mode as revertive for an mpls l2-circuit.

Use the `no` form of this command to remove the vc-mode.

Command Syntax

```
vc-mode revertive
no vc-mode revertive
```

Parameters

None

Command Mode

access-if-vpws mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-vpws
(config-acc-if-vpws)#mpls-l2-circuit vc1 primary
(config-acc-if-vpws)#mpls-l2-circuit vc2 secondary
(config-acc-if-vpws)#vc-mode revertive
(config-acc-if-vpws)#end
```

access-if-vpls

Use this command in L2 subinterface mode to create the vpls access-port.

Use the `no` form of this command to delete the vpls access port

Command Syntax

```
access-if-vpls
no access-if-vpls
```

Parameters

None

Command Mode

L2 Sub-interface mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-vpls
(config-acc-if-vpls)#end
```

mpls-vpls

Use this command to bind a VPLS instance to an L2 subinterface.

Use the `no` form of this command to unbind vpls instance from a L2 subinterface.

Command Syntax

```
mpls-vpls NAME
no mpls-vpls NAME
```

Parameters

NAME	VPLS instance name
------	--------------------

Command Mode

access-if-vpls mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.2 switchport
(config-if)#access-if-vpls
(config-acc-if-vpls)#mpls-vpls v100
(config-acc-if-vpls)#end
```

learning disable

Use this command to disable learning on a particular Attachment Circuit (AC) interface.

Use the `no` form of this command to enable learning on a particular AC interface.

Note: This command disables MAC learning only on that interface.

Command Syntax

```
learning disable
no learning disable
```

Parameters

None

Command Mode

access-if-vpls mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.2 switchport
(config-if)#access-if-vpls
(config-acc-if-vpls)#learning disable
(config-acc-if-vpls)#end
```

split-horizon (subinterface)

Use this command to configure split-horizon group for L2 sub-interface.

Use the `no` form of this command to remove split-horizon group from L2 sub-interface.

Command Syntax

```
split-horizon group (network | access1 | access2)
no split-horizon group
```

Parameters

<code>network</code>	Split-horizon group name network
<code>access1</code>	Split-horizon group name access1
<code>access2</code>	Split-horizon group name access2

Default

By default, split horizon is disabled.

Command Mode

Interface mode

Applicability

This command was introduced in OcNOS version 6.3.0 and applicable only on Qumran1 devices..

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#split-horizon group access1
(config-if)#no split-horizon group
```

static-mac

Use this command to add a static MAC address to an attachment circuit specific for a VPLS instance.

Use the `no` parameter with this command to remove static MAC address.

Command Syntax

```
static-mac XXXX.XXXX.XXXX
no static-mac XXXX.XXXX.XXXX
```

Parameters

XXXX.XXXX.XXXX MAC address in HHHH.HHHH.HHHH format

Command Mode

access-if-vpls mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.2 switchport
(config-if)#access-if-vpls
(config-acc-if-vpls)#static-mac 0091.0000.1010
(config-acc-if-vpls)#end
```

Layer 2 Virtual Private network Configuration

CHAPTER 1

L2VPN FAT SUPPORT

This chapter contains configurations of L2VPN with FAT support.

This is a functional level test plan scoped for the Flow-Aware Transport (FAT) of pseudowire (PW) over an MPLS packet switched network for load-balancing traffic across LDP-based signaled pseudowire for Virtual Private LAN Services (VPLS) and Virtual Private Wire Service (VPWS).

Topology

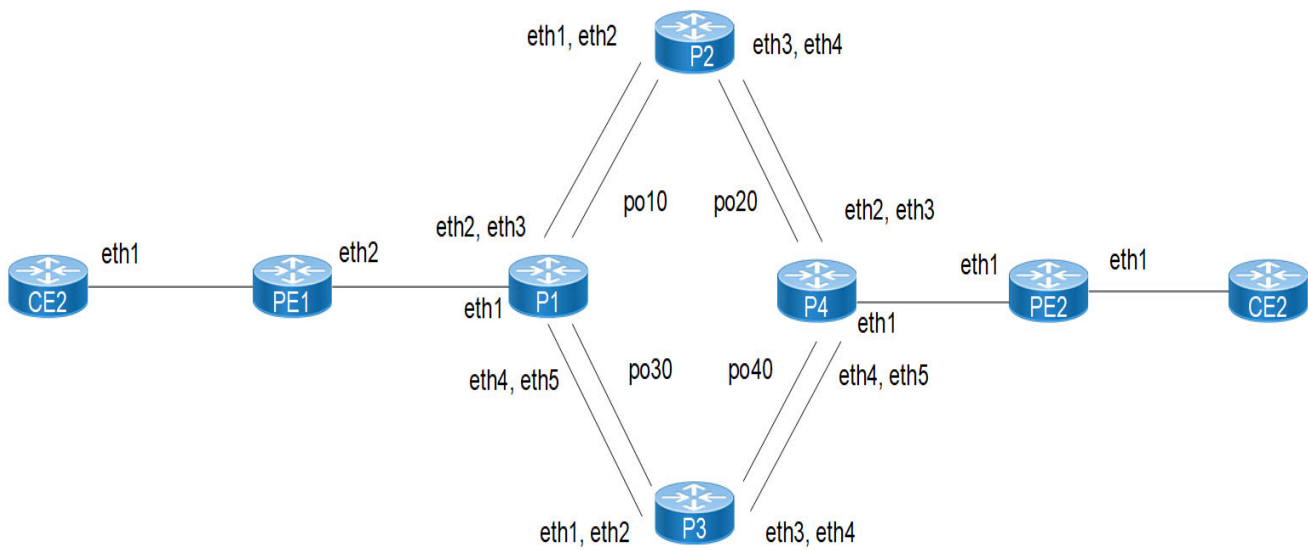


Figure 1-11: L2VPN configuration topology

Configuration for VPLS with FAT

PE-1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 1.1.1.1	Configure Router-id
(config-router)#targeted-peer ipv4 6.6.6.6	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode

(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface eth2	Enter interface mode
(config-if)#ip address 10.1.1.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 1.1.1.1	Configure ospf Router-id
(config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 1.1.1.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#mpls vpls vpls100 100	Configuring VPLS instance with name and VPLS ID
PE1 (config-vpls)#flow-label both	Configure flow label based on requirement (we have three options both, transit and receive) with dynamic and static.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance
(config-vpls-sig)#vpls-peer 6.6.6.6	Configuring VPLS mesh peers
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config-if)#interface eth2.100 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls vpls100	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#commit	Commit the configuration
(config-acc-if-vpls)#end	Return to privilege mode

P1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 2.2.2.2	Configure Router-id

(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface eth1	Enter interface mode
(config-if)#ip address 10.1.1.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po10	Enter interface mode
(config-if)#ip address 10.1.2.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po30	Enter interface mode
(config-if)#ip address 10.1.3.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#interface eth5	Enter the Interface mode for eth5
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure ospf Router-id
(config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.2.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.

(config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 3.3.3.3	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface po10	Enter interface mode
(config-if)#ip address 10.1.2.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth1	Enter the Interface mode for eth1
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po20	Enter interface mode
(config-if)#ip address 10.1.4.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure ospf Router-id
(config-router)#network 10.1.2.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 3.3.3.3/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P3

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 4.4.4.4/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 4.4.4.4	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface po30	Enter interface mode
(config-if)#ip address 10.1.3.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth1	Enter the Interface mode for eth1
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po40	Enter interface mode
(config-if)#ip address 10.1.5.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer, identifying the routing process
(config-router)#ospf router-id 4.4.4.4	Configure ospf Router-id
(config-router)#network 10.1.3.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.5.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 4.4.4.4/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P4

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 5.5.5.5/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 5.5.5.5	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface eth1	Enter interface mode
(config-if)#ip address 10.1.6.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po20	Enter interface mode
(config-if)#ip address 10.1.4.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth2	Enter the Interface mode for eth2

(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po40	Enter interface mode
(config-if)#ip address 10.1.5.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#interface eth5	Enter the Interface mode for eth5
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 5.5.5.5	Configure ospf Router-id
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.5.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.6.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 5.5.5.5/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

PE-2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 6.6.6.6/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 6.6.6.6	Configure Router-id
(config-router)#targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode

(config-router)#transport-address ipv4 6.6.6.6	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface eth2	Enter interface mode
(config-if)#ip address 10.1.6.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the routing process and specify the Process ID(100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 6.6.6.6	Configure ospf Router-id
(config-router)#network 10.1.6.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 6.6.6.6/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#mpls vpls vpls100 100	Configuring VPLS instance with name and VPLS ID
PE1(config-vpls)#flow-label both	Configure flow label based on requirement (we have three options both, transit and receive) with dynamic and static.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance
(config-vpls-sig)#vpls-peer 1.1.1.1	Configuring VPLS mesh peers
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config-if)#interface eth2.100 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls vpls100	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#commit	Commit the configuration
(config-acc-if-vpls)#end	Return to privilege mode

Validation

PE1

```
PE1#show mpls vpls bgp_vpls100 mesh
(m) - Service mapped over multipath transport
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St
PW-INDEX	SIG-Protocol	Status				

100	6.6.6.6	24961	24963	xe4	24963	2/Up	1
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LDP

Active

PE1#

PE1#show mpls vpls vpls100 detail

Virtual Private LAN Service Instance: vpls100, ID: 100

SIG-Protocol: LDP

Attachment-Circuit :UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Enabled, Direction: Both, Static: No

Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500

Description: none

service-tpid: dot1q

Operating mode: Raw

Configured interfaces:

Interface: xe18.100

Subinterface Match Criteria(s) :

dot1q 100

Mesh Peers:

6.6.6.6 (Up)

#ping mpls vpls 200 peer 6.6.6.6/32

Sending 5 MPLS Echos to VPLS Id : 100, timeout is 5 seconds

Codes:

'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

Type 'Ctrl+C' to abort

!
!
!
!
!

Success Rate is 100.00 percent (5/5)

PE2

===

PE2#show mpls vpls vpls200 mesh

(m) - Service mapped over multipath transport

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St
200	1.1.1.1	24961	24963	xe4	24963	2/Up

BGP

Active

PE2#

PE1#show mpls vpls vpls100 detail

Virtual Private LAN Service Instance: vpls100, ID: 100

SIG-Protocol: LDP

Attachment-Circuit :UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Enabled, Direction: Both, Static: No

Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500

Description: none

service-tpid: dot1q

Operating mode: Raw

Configured interfaces:

Interface: xe18.100

Subinterface Match Criteria(s) :

dot1q 100

Mesh Peers:

1.1.1.1 (Up)

#ping mpls vpls 200 peer 1.1.1.1/32

Sending 5 MPLS Echos to VPLS Id : 100, timeout is 5 seconds

Codes:

'!' - Success, 'Q' - request not sent, '.' - timeout,
 'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
 'N' - LBL Mapping Err, 'D' - DS Mismatch,
 'U' - Unknown Interface, 'R' - Transit (LBL Switched),
 'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
 'P' - Protocol Error, 'X' - Unknown code,
 'Z' - Reverse FEC Validation Failed

Type 'Ctrl+C' to abort

!
!
!
!
!

Success Rate is 100.00 percent (5/5)

P1

==

P1#clear interface counters

P1#show interface counters rate mbps

Interface	Rx mbps	Rx pps	Tx mbps	Tx pps
Po10	1549.80	1265260	1034.60	844649
Po30	0.01	8	0.00	8
xe4	1034.60	844647	1549.80	1265257
xe10	0.00	0	0.00	0
xe11	0.00	0	0.00	0
xe12	943.60	773213	474.05	384785
xe13	0.00	4	0.00	4
xe16	606.20	492047	560.54	459865
xe17	0.00	0	0.00	0
xe19	0.00	4	0.00	4

P1#

P4

==

P4#clear interface counters

P4#show interface counters rate mbps

Interface	Rx mbps	Rx pps	Tx mbps	Tx pps
Po20	1549.80	1265260	1034.60	844649
Po40	0.01	8	0.00	8
xe4	1034.60	844647	1549.80	1265257
xe10	0.00	0	0.00	0
xe11	0.00	0	0.00	0
xe12	943.60	773213	474.05	384785
xe13	0.00	4	0.00	4
xe16	606.20	492047	560.54	459865
xe17	0.00	0	0.00	0
xe19	0.00	4	0.00	4

P1#

Configuration for BGP VPLS with FAT

PE-1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP

(config-router)#router-id 1.1.1.1	Configure Router-id
(config-router)#targeted-peer ipv4 6.6.6.6	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface eth2	Enter interface mode
(config-if)#ip address 10.1.1.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 1.1.1.1	Configure ospf Router-id
(config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 1.1.1.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#mpls vpls bgp_vpls200 200	Configuring VPLS instance with name and VPLS ID
PE1(config-vpls)#flow-label both	Configure flow label based on requirement (we have three options both, transit and receive) with dynamic and static.
(config-vpls)#signaling bgp	Enabling BGP signaling for the VPLS instance
(config-vpls-sig)#ve-id 500	Configure VE ID, which is mandatory for BGP VPLS, otherwise, Signaling does not take place. VE ID should be unique per VPLS instance.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config-if)#interface eth2.200 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 200	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls bgp_vpls200	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#commit	Commit the configuration
(config-acc-if-vpls)#end	Return to privilege mode
#configure terminal	Enter configuration mode.
(config)#router bgp 100	Enter BGP router mode.
(config-router)#neighbor 6.6.6.6 remote-as 100	Configure PE2 as an iBGP peer.

(config-router)#neighbor 6.6.6.6 updatesource lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family l2vpn vpls	Configure address-family l2vpn vpls.
(config-router-af)#neighbor 6.6.6.6 activate	Activate PE2 in the VPLS address family.
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#exit	Exit router mode.

P1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 2.2.2.2	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface eth1	Enter interface mode
(config-if)#ip address 10.1.1.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po10	Enter interface mode
(config-if)#ip address 10.1.2.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po30	Enter interface mode
(config-if)#ip address 10.1.3.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#interface eth5	Enter the Interface mode for eth5
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure ospf Router-id
(config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.2.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 3.3.3.3	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface po10	Enter interface mode
(config-if)#ip address 10.1.2.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth1	Enter the Interface mode for eth1
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#exit	Exit interface mode

(config)#commit	Commit the transaction.
(config)#interface po20	Enter interface mode
(config-if)#ip address 10.1.4.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure ospf Router-id
(config-router)#network 10.1.2.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 3.3.3.3/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P3

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 4.4.4.4/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 4.4.4.4	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface po30	Enter interface mode
(config-if)#ip address 10.1.3.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

(config-if)#interface eth1	Enter the Interface mode for eth1
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po40	Enter interface mode
(config-if)#ip address 10.1.5.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 4.4.4.4	Configure ospf Router-id
(config-router)#network 10.1.3.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.5.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 4.4.4.4/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P4

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 5.5.5.5/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 5.5.5.5	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface eth1	Enter interface mode

(config-if)#ip address 10.1.6.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po20	Enter interface mode
(config-if)#ip address 10.1.4.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po40	Enter interface mode
(config-if)#ip address 10.1.5.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#interface eth5	Enter the Interface mode for eth5
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 5.5.5.5	Configure ospf Router-id
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.5.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.6.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 5.5.5.5/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

PE-2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 6.6.6.6/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 6.6.6.6	Configure Router-id
(config-router)#targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)#transport-address ipv4 6.6.6.6	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface eth2	Enter interface mode
(config-if)#ip address 10.1.6.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 6.6.6.6	Configure ospf Router-id
(config-router)#network 10.1.6.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 6.6.6.6/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#mpls vpls bgp_vpls200 200	Configuring VPLS instance with name and VPLS ID
PE1 (config-vpls)#flow-label both	Configure flow label based on requirement (we have three options both, transit and receive) with dynamic and static.
(config-vpls)#signaling bgp	Enabling BGP signaling for the VPLS instance
(config-vpls-sig)#ve-id 600	Configure VE ID, which is mandatory for BGP VPLS, otherwise, Signaling does not take place. VE ID should be unique per VPLS instance.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config-if)#interface eth2.200 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 200	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface

(config-acc-if-vpls)#mpls-vpls bgp_vpls200	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#commit	Commit the configuration
(config-acc-if-vpls)#end	Return to privilege mode
(config)#router bgp 100	Enter BGP router mode.
(config-router)#neighbor 1.1.1.1 remote-as 100	Configure PE1 as an iBGP peer.
(config-router)#neighbor 1.1.1.1 updatesource lo	Update the source as loopback for iBGP peering with the remote PE1 router.
(config-router)#address-family l2vpn vpls	Configure address-family l2vpn vpls.
(config-router-af)#neighbor 1.1.1.1 activate	Activate PE1 in the VPLS address family.
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#exit	Exit router mode.

Validation

PE1

```
PE1#show mpls vpls bgp_vpls200 mesh
(m) - Service mapped over multipath transport
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St
PW-INDEX	SIG-Protocol	Status				
200	6.6.6.6	24961	24963	xe4	24963	2/Up
BGP	Active					1

PE1#

```
PE1#show mpls vpls bgp_vpls200 detail
```

Virtual Private LAN Service Instance: bgp_vpls200, ID: 200

SIG-Protocol: BGP

Route-Distinguisher :100:200

Route-Target :100:200

VE-ID :500

Attachment-Circuit :UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Enabled, Direction: Receive, Static: No

Group ID: 0, Configured MTU: 1500

Description: none

service-tpid: dot1q

Operating mode: Raw

Configured interfaces:

Interface: eth1.200

Subinterface Match Criteria(s) :

dot1q 300

Mesh Peers:

6.6.6.6 (Up)

```
#ping mpls bgp_vpls 200 peer 6.6.6.6/32
Sending 5 MPLS Echos to VPLS Id : 100, timeout is 5 seconds
```

Codes:

```
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
```

Type 'Ctrl+C' to abort

```
!
!
!
!
!
```

Success Rate is 100.00 percent (5/5)

PE2

===

```
PE2#show mpls vpls bgp_vpls200 mesh
(m) - Service mapped over multipath transport
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St
PW-INDEX	SIG-Protocol	Status				
200	1.1.1.1	24961	24963	xe4	24963	2/Up 1
BGP	Active					

PE2#

```
PE1#show mpls vpls bgp_vpls200 detail
```

Virtual Private LAN Service Instance: bgp_vpls200, ID: 200

SIG-Protocol: BGP

Route-Distinguisher :100:200

Route-Target :100:200

VE-ID :500

Attachment-Circuit :UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Enabled, Direction: Transmit, Static: No

Group ID: 0, Configured MTU: 1500

Description: none

service-tpid: dot1q

Operating mode: Raw

Configured interfaces:

Interface: eth1.200

Subinterface Match Criteria(s) :

dot1q 200

Mesh Peers:

1.1.1.1 (Up)

```
#ping mpls bgp_vpls 200 peer 1.1.1.1/32
Sending 5 MPLS Echos to VPLS Id : 100, timeout is 5 seconds
```

Codes:

```
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
```

Type 'Ctrl+C' to abort

```
!
!
!
!
!
```

Success Rate is 100.00 percent (5/5)

P1

==

P1#clear interface counters

P1#show interface counters rate mbps

Interface	Rx mbps	Rx pps	Tx mbps	Tx pps
Po10	1549.80	1265260	1034.60	844649
Po30	0.01	8	0.00	8
xe4	1034.60	844647	1549.80	1265257
xe10	0.00	0	0.00	0
xe11	0.00	0	0.00	0
xe12	943.60	773213	474.05	384785
xe13	0.00	4	0.00	4
xe16	606.20	492047	560.54	459865
xe17	0.00	0	0.00	0
xe19	0.00	4	0.00	4

P1#

P4

==

P4#clear interface counters

```
P4#show interface counters rate mbps
```

Interface	Rx mbps	Rx pps	Tx mbps	Tx pps
Po20	1549.80	1265260	1034.60	844649
Po40	0.01	8	0.00	8
xe4	1034.60	844647	1549.80	1265257
xe10	0.00	0	0.00	0
xe11	0.00	0	0.00	0
xe12	943.60	773213	474.05	384785
xe13	0.00	4	0.00	4
xe16	606.20	492047	560.54	459865
xe17	0.00	0	0.00	0
xe19	0.00	4	0.00	4

```
P1#
```

Configuration for VPWS with FAT

PE-1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 1.1.1.1	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config-router)#targeted-peer ipv4 6.6.6.6	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface eth2	Enter interface mode
(config-if)#ip address 10.1.1.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.

(config-router)#ospf router-id 1.1.1.1	Configure ospf Router-id
(config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 1.1.1.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#mpls l2-circuit VPWS4 400 3.3.3.3	Configure the VC for PE-2
PE1(config-vpls)#flow-label both	Configure flow label based on requirement (we have three options both, transit and receive) with dynamic and static.
(config-pseudowire)#commit	Commit the configuration
(config-pseudowire)#exit	Exit from pseudowire configuration mode
(config-if)#interface eth2.300 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 300	Configure encapsulation under a subinterface
(config-if)#access-if-vpws	Access VPWS under sub interface
(config-acc-if-vpws)#mpls-l2-circuit VPWS4 primary	Associating the VPWS Instance to the attachment circuit interface.
(config-acc-if-vpws)#commit	Commit the configuration
(config-acc-if-vpws)#end	Return to privilege mode

P1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 2.2.2.2	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface eth1	Enter interface mode
(config-if)#ip address 10.1.1.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po10	Enter interface mode
(config-if)#ip address 10.1.2.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po30	Enter interface mode
(config-if)#ip address 10.1.3.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#interface eth5	Enter the Interface mode for eth5
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure ospf Router-id
(config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.2.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 3.3.3.3	Configure Router-id
(config-router)#commit	Commit the transaction.

(config-router)#exit	Exit from router mode
(config)#interface po10	Enter interface mode
(config-if)#ip address 10.1.2.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth1	Enter the Interface mode for eth1
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po20	Enter interface mode
(config-if)#ip address 10.1.4.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure ospf Router-id
(config-router)#network 10.1.2.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 3.3.3.3/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P3

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 4.4.4.4/32 secondary	Configure IP address for the loopback interface

<code>(config-if)#commit</code>	Commit the configuration
<code>(config-if)#exit</code>	Exit interface mode
<code>(config)#router ldp</code>	Enter router mode for LDP
<code>(config-router)#router-id 4.4.4.4</code>	Configure Router-id
<code>(config-router)#commit</code>	Commit the transaction.
<code>(config-router)#exit</code>	Exit from router mode
<code>(config)#interface po30</code>	Enter interface mode
<code>(config-if)#ip address 10.1.3.2/24</code>	Configure IP address on interface
<code>(config-if)#label-switching</code>	Enable label switching capability on the interface
<code>(config-if)#enable-ldp ipv4</code>	Enabling LDP on the interface
<code>(config-if)#commit</code>	Commit the configuration
<code>(config-if)#exit</code>	Exit interface mode
<code>(config-if)#interface eth1</code>	Enter the Interface mode for eth1
<code>(config-if)#channel-group 30 mode active</code>	Moving interface to Dynamic LAG 30
<code>(config-if)#interface eth2</code>	Enter the Interface mode for eth2
<code>(config-if)#channel-group 30 mode active</code>	Moving interface to Dynamic LAG 30
<code>(config-if)#exit</code>	Exit interface mode
<code>(config)#commit</code>	Commit the transaction.
<code>(config)#interface po40</code>	Enter interface mode
<code>(config-if)#ip address 10.1.5.2/24</code>	Configure IP address on interface
<code>(config-if)#label-switching</code>	Enable label switching capability on the interface
<code>(config-if)#enable-ldp ipv4</code>	Enabling LDP on the interface
<code>(config-if)#commit</code>	Commit the configuration
<code>(config-if)#exit</code>	Exit interface mode
<code>(config-if)#interface eth3</code>	Enter the Interface mode for eth3
<code>(config-if)#channel-group 40 mode active</code>	Moving interface to Dynamic LAG 40
<code>(config-if)#interface eth4</code>	Enter the Interface mode for eth4
<code>(config-if)#channel-group 40 mode active</code>	Moving interface to Dynamic LAG 40
<code>(config-if)#exit</code>	Exit interface mode
<code>(config)#commit</code>	Commit the transaction.
<code>(config)#router ospf 100</code>	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
<code>(config-router)#ospf router-id 4.4.4.4</code>	Configure ospf Router-id
<code>(config-router)#network 10.1.3.0/24 area 0</code>	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
<code>(config-router)#network 10.1.5.0/24 area 0</code>	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
<code>(config-router)#network 4.4.4.4/32 area 0</code>	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
<code>(config-router)#commit</code>	Commit the transaction.
<code>(config-router)#exit</code>	Exit from router mode

P4

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 5.5.5.5/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 5.5.5.5	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface eth1	Enter interface mode
(config-if)#ip address 10.1.6.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po20	Enter interface mode
(config-if)#ip address 10.1.4.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po40	Enter interface mode
(config-if)#ip address 10.1.5.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#interface eth5	Enter the Interface mode for eth5
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 5.5.5.5	Configure ospf Router-id
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.5.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.6.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 5.5.5.5/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

PE-2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 6.6.6.6/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 6.6.6.6	Configure Router-id
(config-router)#targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)#transport-address ipv4 6.6.6.6	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface eth2	Enter interface mode
(config-if)#ip address 10.1.6.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 6.6.6.6	Configure ospf Router-id
(config-router)#network 10.1.6.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 6.6.6.6/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the configuration

(config-router)#exit	Exit from router mode
(config)#mpls l2-circuit VPWS4 400 1.1.1.1	Configure the VC for PE-2
PE1(config-vpls)#flow-label both	Configure flow label based on requirement (we have three options both, transit and receive) with dynamic and static.
(config-pseudowire)#commit	Commit the configuration
(config-pseudowire)#exit	Exit from pseudowire configuration mode
(config-if)#interface eth2.300 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 300	Configure encapsulation under a subinterface
(config-if)#access-if-vpws	Access VPWS under sub interface
(config-acc-if-vpws)#mpls-l2-circuit VPWS4 primary	Associating the VPWS Instance to the attachment circuit interface.
(config-acc-if-vpws)#commit	Commit the configuration
(config-acc-if-vpws)#end	Return to privilege mode

Validation

PE1

```
PE1#show mpls vc-table
(m) - Service mapped over multipath transport
```

VC-ID	Vlan-ID	Inner-Vlan-ID	Access-Intf	Network-Intf	Out Label	Tunnel-Label
Nexthop	Status					
400	N/A	N/A	xe18.300	xe4	24967	24961
6.6.6.6	Active					

```
PE1#
PE1#show mpls l2-circuit detail
MPLS Layer-2 Virtual Circuit: VPWS4, id: 300 PW-INDEX: 4 service-tpid: dot1.q
Endpoint: 6.6.6.6
Control Word: 0
Flow Label Status: Enabled, Direction: Both, Static: Yes
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe18.200
Subinterface Match Criteria(s) :
dot1q 300
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
```

PE2

===

```
PE2#show mpls vc-table
(m) - Service mapped over multipath transport
```

VC-ID	Vlan-ID	Inner-Vlan-ID	Access-Intf	Network-Intf	Out Label	Tunnel-Label
Nexthop	Status					

400	N/A	N/A	xe4.300	xe18	24967	24961
1.1.1.1	Active					

PE2#

PE2#show mpls l2-circuit detail

MPLS Layer-2 Virtual Circuit: VPWS4, id: 300 PW-INDEX: 4 service-tpid: dot1.q

Endpoint: 1.1.1.1

Control Word: 0

Flow Label Status: Enabled, Direction: Both, Static: Yes

MPLS Layer-2 Virtual Circuit Group: none

Bound to interface: xe4.200

Subinterface Match Criteria(s) :

dot1q 200

Virtual Circuit Type: Ethernet VLAN

Virtual Circuit is configured as Primary

Virtual Circuit is configured as Active

Virtual Circuit is active

P1

==

P1#clear interface counters

P1#show interface counters rate mbps

Interface	Rx mbps	Rx pps	Tx mbps	Tx pps
Po10	1549.80	1265260	1034.60	844649
Po30	0.01	8	0.00	8
xe4	1034.60	844647	1549.80	1265257
xe10	0.00	0	0.00	0
xe11	0.00	0	0.00	0
xe12	943.60	773213	474.05	384785
xe13	0.00	4	0.00	4
xe16	606.20	492047	560.54	459865
xe17	0.00	0	0.00	0
xe19	0.00	4	0.00	4

P1#

P4

==

P4#clear interface counters

P4#show interface counters rate mbps

Interface	Rx mbps	Rx pps	Tx mbps	Tx pps
Po20	1549.80	1265260	1034.60	844649
Po40	0.01	8	0.00	8
xe4	1034.60	844647	1549.80	1265257
xe10	0.00	0	0.00	0

xe11	0.00	0	0.00	0
xe12	943.60	773213	474.05	384785
xe13	0.00	4	0.00	4
xe16	606.20	492047	560.54	459865
xe17	0.00	0	0.00	0
xe19	0.00	4	0.00	4

P1#

CHAPTER 2 L2VPN Sub Interface Configuration

L2VPN is a layer 2 service where different locations (customer sites) of an enterprise interconnect to form a big LAN segment. All the locations can exchange layer 2 data with each other via this Virtual LAN in a private and secured way.

The MPLS Core-based L2VPN model has two broad divisions:

- Virtual Private Wire Service (VPWS)
- Virtual Private LAN Service (VPLS)

Virtual Private Wire Service or VPWS is a Point-to-Point (P2P) service implementation of L2VPN. It provides layer 2 data flow of the same or different types (FR, ATM, etc.) of L2 services over the MPLS core attaching the two customer sites.

Virtual Private LAN Service (VPLS) is a Point-to-Multipoint (P2MP) and Multipoint-to-Multipoint (MP2MP) L2VPN service. VPLS is designed for applications that require multipoint access across geographically distributed locations. Using VPLS, several customer sites (or distributed Ethernet LANs) can be interconnected to work as a single bridged domain over the MPLS network. In simple terms, VPLS uses the Layer 2 architecture to create multipoint VPNs that connect several sites over a Wide Area Network (WAN) or Metropolitan Area Network (MAN). The different customer sites are connected via the Service Provider's MPLS core network.

Topology

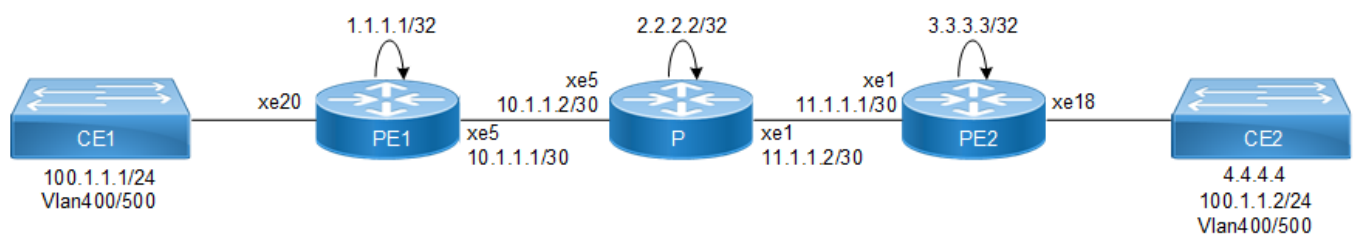


Figure 2-12: Link detection debounce timer topology

VPLS Configuration

All configuration commands in the table below should be followed for each Router.

PE1

#configure terminal	Enter Configure mode.
(config)#router isis 1	Create an IS-IS routing instance for area 49
(config-router)#net 49.3600.3600.0001.00	Set a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

(config)#interface xe5	Enter interface mode
(config-if)#ip address 10.1.1.1/30	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 1.1.1.1	Configure Router-id
(config-router)#targeted-peer ipv4 3.3.3.3	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#mpls vpls vpls100 100	Configuring VPLS instance with name and VPLS ID
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance
(config-vpls-sig)#vpls-peer 3.3.3.3	Configuring VPLS mesh peers
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config-if)#interface xe20.100 switchport	Enter sub interface mode
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls vpls100	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#commit	Commit the configuration
(config-acc-if-vpls)#end	Return to privilege mode

P

#configure terminal	Enter Configure mode.
(config)#router isis 1	Create an IS-IS routing instance for area 49
(config-router)#net 49.3600.3600.0003.00	Set a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface lo	Enter interface mode
(config-if)# ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 2.2.2.2	Configure Router-id
(config-router)# transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit router mode
(config)#interface xe5	Enter interface mode
(config-if)#ip address 10.1.1.2/30	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter interface mode
(config-if)# ip address 11.1.1.2/30	Configure IP address on interface
(config-if)# label-switching	Enable label switching capability on the interface
(config-if)# ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)# enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

PE2

#configure terminal	Enter Configure mode.
(config)#router isis 1	Create an IS-IS routing instance for area 49
(config-router)#net 49.3600.3600.0002.00	Set a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface lo	Enter interface mode
(config-if)# ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)# router-id 3.3.3.3	Configure Router-id
(config-router)# targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE-1
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)# transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration

(config-router)#exit	Exit from router mode
(config)#interface xe1	Enter interface mode
(config-if)#ip address 11.1.1.1/30	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configurations
(config-if)#exit	Exit interface mode
(config)#mpls vpls vpls100 100	Configuring VPLS instance with name and VPLS ID
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance
(config-vpls-sig)#vpls-peer 1.1.1.1	Configuring VPLS mesh peers
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config)#interface xe18.100 switchport	Enter sub interface mode
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls vpls100	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#commit	Commit the configuration
(config-acc-if-vpls)#end	Return to privilege mode

Validation

PE1

```
#ping mpls vpls 100 peer 3.3.3.3/32
Sending 5 MPLS Echos to VPLS Id : 100, timeout is 5 seconds
```

Codes:

```
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
```

Type 'Ctrl+C' to abort

```
!
!
!
!
!
```

Success Rate is 100.00 percent (5/5)

```
#show mpls vpls mesh
(m) - Service mapped over multipath transport
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX
100	3.3.3.3	24320	24320	xe5	24320	2/Up	1
Active							

```
#show mpls vpls detail
Virtual Private LAN Service Instance: vpls100, ID: 100
SIG-Protocol: LDP
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1q
Operating mode: Raw
Configured interfaces:
  Interface: xe20.100
Subinterface Match Criteria(s) :
  dot1q 100
Mesh Peers:
  3.3.3.3 (Up)
```

VPWS Configuration

All configuration commands in the table below should be followed for each Router.

PE1

#configure terminal	Enter Configure mode.
(config)#router isis 1	Create an IS-IS routing instance for area 49
(config-router)#net 49.3600.3600.0001.00	Set a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter interface mode
(config-if)#ip address 10.1.1.1/30	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface

(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 1.1.1.1	Configure Router-id
(config-router)#targeted-peer ipv4 3.3.3.3	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#mpls l2-circuit VPWS4 400 3.3.3.3	Configure the VC for PE-2
(config-pseudowire)#commit	Commit the configuration
(config-pseudowire)#exit	Exit from pseudowire configuration mode
(config)#interface xe20.400 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 400	Configure encapsulation under a subinterface
(config-if)#access-if-vpws	Access VPWS under sub interface
(config-acc-if-vpws)#mpls-l2-circuit VPWS4 primary	Associating the VPWS Instance to the attachment circuit interface.
(config-acc-if-vpws)#commit	Commit the configuration
(config-acc-if-vpws)#end	Return to privilege mode

P

#configure terminal	Enter Configure mode.
(config)#router isis 1	Create an IS-IS routing instance for area 49
(config-router)#net 49.3600.3600.0003.00	Set a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface lo	Enter interface mode
(config-if)# ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 2.2.2.2	Configure Router-id
(config-router)# transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit router mode

(config)#interface xe5	Enter interface mode
(config-if)#ip address 10.1.1.2/30	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter interface mode
(config-if)# ip address 11.1.1.2/30	Configure IP address on interface
(config-if)# label-switching	Enable label switching capability on the interface
(config-if)# ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)# enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

PE2

#configure terminal	Enter Configure mode.
(config)#router isis 1	Create an IS-IS routing instance for area 49
(config-router)#net 49.3600.3600.0002.00	Set a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface lo	Enter interface mode
(config-if)# ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)# router-id 3.3.3.3	Configure Router-id
(config-router)# targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE-1
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)# transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface xe1	Enter interface mode
(config-if)#ip address 11.1.1.1/30	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enabling LDP on the interface

(config-if)#commit	Commit the configurations
(config-if)#exit	Exit interface mode
(config)#mpls l2-circuit VPWS4 400 1.1.1.1	Configure the VC for PE-1
(config-pseudowire)#commit	Commit the configuration
(config-pseudowire)#exit	Exit from pseudowire configuration mode
(config)#interface xe18.400 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 400	Configure encapsulation under a subinterface
(config-if)#access-if-vpws	Access VPWS under sub interface
(config-acc-if-vpws)#mpls-l2-circuit VPWS4 primary	Associating the VPWS Instance to the attachment circuit interface.
(config-acc-if-vpws)#commit	Commit the configuration
(config-acc-if-vpws)#end	Return to privilege mode
(config)#mpls l2-circuit VPWS4 400 1.1.1.1	Configure the VC for PE-1
(config-pseudowire)#commit	Commit the configuration

Validation

PE1

```
#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: VPWS4, id: 400  PW-INDEX: 4 Endpoint: 3.3.3.3
Control Word: 0
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe20.400
Subinterface Match Criteria(s) :
  dot1q 400
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
```

```
#show ldp mpls-l2-circuit
Transport      Client      VC      VC      Local      Remote      Destination
VC ID          Binding    State   Type      VC Label    VC Label    Address
400            xe20.400  UP      Ethernet VLAN 24322      24322      3.3.3.3
```

```
#ping mpls l2-circuit 400
Sending 5 MPLS Echos to VC Id : 400, timeout is 5 seconds
```

Codes:

```
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
```

'Z' - Reverse FEC Validation Failed

Type 'Ctrl+C' to abort

!
!
!
!
!

Success Rate is 100.00 percent (5/5)

CHAPTER 3 Virtual Private LAN Service Configuration

This chapter contains configurations for Virtual Private LAN Service (VPLS).

VPLS Raw Mode

The examples show the minimum configuration required for enabling a VPLS Mesh peer between PE1, PE2, and PE3 in raw mode.

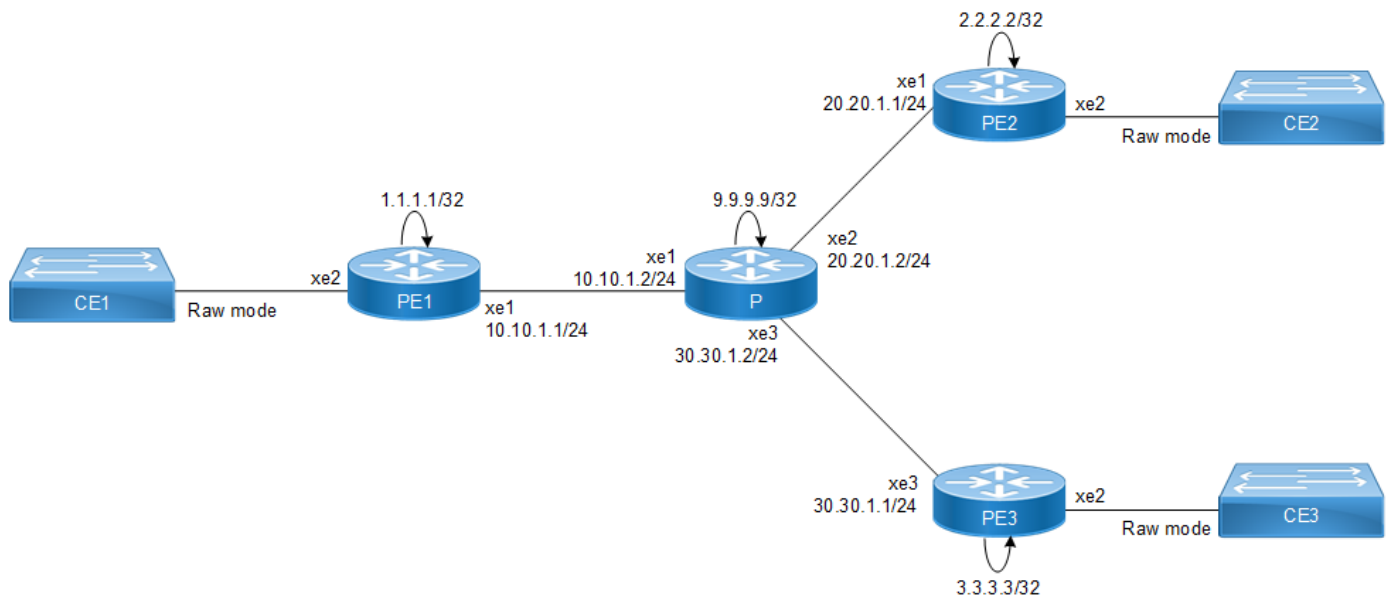


Figure 3-13: VPLS Mesh Peers Raw Mode

Configuration

PE1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface (xe1) to be configured.
(config-if)#ip address 10.10.1.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the routing process ID (100).
(config-router)#network 10.10.1.0/24 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#network 1.1.1.1/32 area 0	
(config-router)#exit	Exit router mode.

(config)#router ldp	Enter router mode for LDP.
(config-router)# router-id 1.1.1.1	Configure the router-id
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run.
(config-router)#targeted-peer ipv4 2.2.2.2	Configuring targeted LDP sessions to PE2
(config-router-targeted-peer)#exit	Exit config-router-targeted-peer mode
(config-router)#targeted-peer ipv4 3.3.3.3	Enter targeted-peer-mode and PE3
(config-router-targeted-peer)#exit	Exit config-router-targeted-peer mode
(config-router)#exit	Exit router configuration mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#mpls vpls VPLS1 100	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls-sig)#vpls-peer 2.2.2.2 (config-vpls-sig)#vpls-peer 3.3.3.3	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe2	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.
(config-if)mpls-vpls VPLS1 service-template st1	Associating the VPLS Instance to the attachment circuit interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

P

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 9.9.9.9/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface to be configured.
(config-if)#ip address 10.10.1.2/24	Configure IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 20.20.1.2/24	Configure IP address for the interface.

(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#ip address 30.30.1.2/24	Configure IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#network 10.10.1.0/24 area 0 (config-router)#network 20.20.1.0/24 area 0 (config-router)#network 30.30.1.0/24 area 0 (config-router)#network 9.9.9.9/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the Interface address.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 9.9.9.9	Confirm the router-id
(config-router)#transport-address ipv4 9.9.9.9	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface configuration mode.
(config)#interface xe2	Specify the interface to be configured.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

PE2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface (xe1) to be configured.
(config-if)#ip address 20.20.1.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively brining up the interface.
(config-if)#exit	Exit interface mode.

(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#network 20.20.1.0/24 area 0 (config-router)#network 2.2.2.2/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 2.2.2.2	Confirm the router-id
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run.
(config-router)#targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE2.
(config-router-targeted-peer)#exit	Exit targeted-peer-mode
(config-router)#targeted-peer ipv4 3.3.3.3	Configuring targeted LDP sessions to PE3
(config-router-targeted-peer)#exit	Exit targeted-peer-mode
(config-router)#exit	Exit router configuration mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#mpls vpls VPLS1 100	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls-sig)#vpls-peer 1.1.1.1 (config-vpls-sig)#vpls-peer 3.3.3.3	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#service-template st1	Template configuration.
(config-svc)#exit	Exit service template mode.
(config)#interface xe2	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.
(config-if)mpls-vpls VPLS1 service-template st1	Associating the VPLS Instance to the attachment circuit interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

PE3

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface (xe1) to be configured.

(config-if)#ip address 30.30.1.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bring up the interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#network 30.30.1.0/24 area 0 (config-router)#network 3.3.3.3/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 3.3.3.3	Confirm the router-id
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run.
(config-router)#targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE2
(config-router-targeted-peer)#exit	Exit targeted-peer-mode
(config-router)#targeted-peer ipv4 2.2.2.2	Configuring targeted LDP sessions to PE3
(config-router-targeted-peer)#exit	Exit targeted-peer-mode
(config-router)#exit	Exit router configuration mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#mpls vpls VPLS1 100	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls-sig)#vpls-peer 1.1.1.1 (config-vpls-sig)#vpls-peer 2.2.2.2	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#service-template st1	Template configuration.
(config-svc)#exit	Exit service template mode.
(config)#interface xe2	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.
(config-if)mpls-vpls VPLS1 service-template st1	Associating the VPLS Instance to the attachment circuit interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

Validation

PE1

Verify VPLS Session

```
PE1#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
  SIG-Protocol: LDP
  Attachment-Circuit :UP
  Learning: Enabled
  Control-Word: Disabled
  Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
  Description: none
  service-tpid: dot1.q
  Operating mode: Raw
  Configured interfaces:
    Interface: xe2
  Service-template : st1
  Match criteria : Accept all
```

```
Mesh Peers:
  2.2.2.2 (Up)
  3.3.3.3 (Up)
```

```
PE1#
```

Verify VPLS Mesh Peer

```
PE1#sh mpls vpls mesh
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX	SIG-Protocol	Status
100	2.2.2.2	24325	24321	xe1	24321	2/Up	1	LDP	Active
100	3.3.3.3	24322	24320	xe1	24321	2/Up	2	LDP	Active

```
PE1#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe1	Passive	OPERATIONAL	30	00:32:21
3.3.3.3	xe1	Passive	OPERATIONAL	30	00:20:50
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:34:18

```
PE1#show ip ospf neighbor
```

```
Total number of full neighbors: 1
```

```
OSPF process 100 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.145	1	Full/Backup	00:00:35	10.10.1.2	xe1	0

```
P#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:40:04
2.2.2.2	xe2	Active	OPERATIONAL	30	00:38:22
3.3.3.3	xe3	Active	OPERATIONAL	30	00:25:57

P#show ip ospf neighbor

Total number of full neighbors: 3

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.142	1	Full/DR	00:00:34	10.10.1.1	xe1	0
10.12.49.144	1	Full/Backup	00:00:29	20.20.1.1	xe2	0
10.12.49.146	1	Full/Backup	00:00:36	30.30.1.1	xe3	0

PE2#show mpls vpls detail

Virtual Private LAN Service Instance: VPLS1, ID: 100

SIG-Protocol: LDP Attachment-Circuit :UP

Learning: Enabled Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No Group ID: 0, VPLS Type: Ethernet,

Configured MTU: 1500

Description: none service-tpid: dot1.q Operating mode: Raw Configured interfaces:

Interface: xe2 Service-template : st1

Match criteria : Accept all

Mesh Peers:

1.1.1.1 (Up)

3.3.3.3 (Up)

PE2#show mpls vpls mesh

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX	SIG-Protocol	Status
100	1.1.1.1	25601	26240	xe1	26240	2/Up	1	LDP	Active
100	3.3.3.3	25603	26241	xe1	26241	2/Up	2	LDP	Active

PE2#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:41:59
3.3.3.3	xe1	Passive	OPERATIONAL	30	00:30:15
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:42:14

PE2#show ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.145	1	Full/DR	00:00:35	20.20.1.2	xe1	0

PE3#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:44:25
2.2.2.2	xe1	Active	OPERATIONAL	30	00:44:13
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:43:47

PE3#show ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.145	1	Full/DR	00:00:33	30.30.1.2	xe1	0

PE3#show mpls vpls detail

Virtual Private LAN Service Instance: VPLS1, ID: 100

```

SIG-Protocol: LDP
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
  Interface: xe2
Service-template : st1
Match criteria : Accept all

Mesh Peers:
  1.1.1.1 (Up)
  2.2.2.2 (Up)

```

```
PE3#show mpls vpls mesh
```

```
(m) - Service mapped over multipath transport
```

```
(e) - Service mapped over LDP ECMP
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX	SIG-Protocol	Status
100	1.1.1.1	25602	26240	xe1	26241	2/Up	1	LDP	Active
100	2.2.2.2	25603	26241	xe1	26241	2/Up	2	LDP	Active

VPLS Tagged Mode

The examples show the minimum configuration required for enabling a VPLS Mesh peer between PE1, PE2, and PE3 in Tagged Mode. In the below example PE1 and PE2 uses VLAN 10 for binding the VPLS instance to the attachment circuit and PE3 used VLAN 20 where it shows that VLAN swapping is supported.

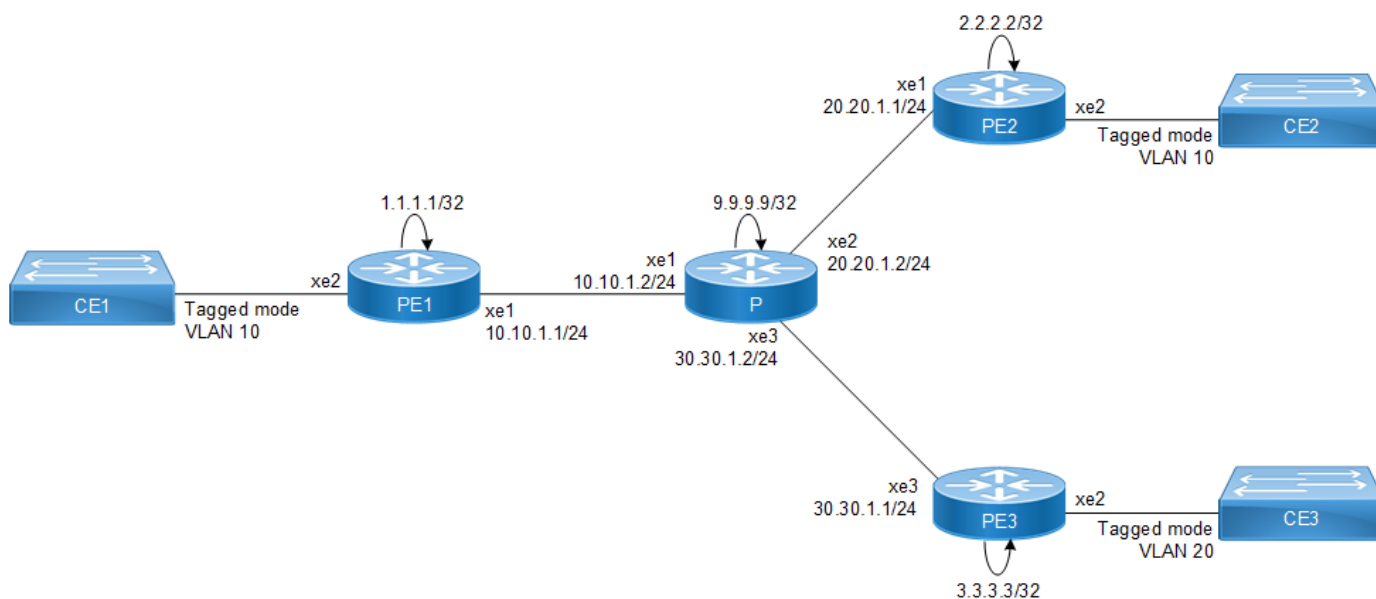


Figure 3-14: VPLS Mesh Peers Tagged Mode

Configuration

PE1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface (xe1) to be configured.
(config-if)#ip address 10.10.1.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#network 10.10.1.0/24 area 0 (config-router)#network 1.1.1.1/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#targeted-peer ipv4 2.2.2.2	Configuring targeted LDP sessions to PE2
(config-router-targeted-peer)#exit	Exit targeted peer mode
(config-router-targeted-peer)#targeted-peer ipv4 3.3.3.3	Configuring targeted LDP sessions to PE3
(config-router-targeted-peer)#exit	Exit targeted peer mode
(config-router)#exit	Exit router configuration mode
(config)#interface xe1	Enter interface mode
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#mpls vpls VPLS1 100	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls-sig)#vpls-type vlan	Configuring VPLS type as VLAN mode.
(config-vpls-sig)#vpls-peer 2.2.2.2 (config-vpls-sig)#vpls-peer 3.3.3.3	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#mpls vpls v4 28	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 2.2.2.2	Configure VPLS Peers
(config-vpls-sig)#vpls-peer 3.3.3.3	Configure VPLS Peers
(config-vpls-sig)#exit-signaling	Exit Signaling LDP mode

(config-vpls)#exit	Exit VPLS mode
(config)#service-template st1	Template configuration.
(config-svc)#match outer-vlan 10	Match criteria under template configuration
(config-svc)#exit	Exit service template mode.
(config)#interface xe2	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.
(config-if)mpls-vpls VPLS1 service-template st1	Associating the VPLS Instance to the attachment circuit interface to match service template st1.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

Service template with Multiple Match Support

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

(config)#service-template template4	Template configuration
(config-svc)#match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)#match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)#match untagged	Allow untagged traffic
(config-svc)#rewrite ingress push 300	Push Action performed for service template
(config-svc)#exit	Exit configure SVC mode
(config)#interface xe2	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.
(config-if)mpls-vpls v4 service-template template4	Associating the VPLS Instance to the attachment circuit interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#commit	Commit the transaction.

P

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 9.9.9.9/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface to be configured.
(config-if)#ip address 10.10.1.2/24	Configure IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 20.20.1.2/24	Configure IP address for the interface.

(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#ip address 30.30.1.2/24	Configure IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#network 10.1.1.0/24 area 0 (config-router)#network 20.20.1.0/24 area 0 (config-router)#network 30.30.1.0/24 area 0 (config-router)#network 9.9.9.9/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the Interface address.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface configuration mode.
(config)#interface xe2	Specify the interface to be configured.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

PE2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface (xe1) to be configured.
(config-if)#ip address 20.20.1.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#network 20.20.1.0/24 area 0 (config-router)#network 2.2.2.2/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#exit	Exit router mode.

(config)#router ldp	Enter router mode for LDP.
(config-router)#targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE2
(config-router-targeted-peer)#exit	Exit targeted peer mode
(config-router-targeted-peer)#targeted-peer ipv4 3.3.3.3	Configuring targeted LDP sessions to PE3
(config-router-targeted-peer)#exit	Exit targeted peer mode
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit targeted peer mode.
(config-router)#exit	Exit router configuration mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#mpls vpls VPLS1 100	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls-sig)#vpls-type vlan	Configuring VPLS type as VLAN mode.
(config-vpls-sig)#vpls-peer 1.1.1.1	Configuring VPLS mesh peers.
(config-vpls-sig)#vpls-peer 3.3.3.3	
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#mpls vpls v4 28	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 1.1.1.1	Configure VPLS Peers
(config-vpls-sig)#vpls-peer 3.3.3.3	Configure VPLS Peers
(config-vpls-sig)#exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#service-template st1	Template configuration.
(config-svc)#match outer-vlan 10	Match criteria under template configuration
(config-svc)#exit	Exit service template mode.
(config)#service-template template4	Template configuration
(config-svc)#match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)#match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)#match untagged	Allow untagged traffic
(config-svc)#rewrite ingress push 300	Push Action performed for service template
(config-svc)#exit	Exit configure SVC mode
(config)#interface xe2	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.
(config-if)mpls-vpls VPLS1 service-template st1	Associating the VPLS Instance to the attachment circuit interface to match service template st1.
(config-if)mpls-vpls v4 service-template template4	Associating the VPLS Instance to the attachment circuit interface.

(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

PE3

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface (xe1) to be configured.
(config-if)#ip address 30.30.1.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively brining up the interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#network 30.30.1.0/24 area 0 (config-router)#network 3.3.3.3/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE2
(config-router-targeted-peer)#exit	Exit targeted peer mode
(config-router-targeted-peer)#targeted-peer ipv4 2.2.2.2	Configuring targeted LDP sessions to PE3
config-router-targeted-peer)#exit	Exit targeted peer mode
(config-router)#exit	Exit router configuration mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#mpls vpls VPLS1 100	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls-sig)#vpls-type vlan	Configuring VPLS type as VLAN mode.
(config-vpls-sig)#vpls-peer 1.1.1.1 (config-vpls-sig)#vpls-peer 2.2.2.2	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#mpls vpls v4 28	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS

(config-vpls-sig)#vpls-peer 1.1.1.1	Configure VPLS Peers
(config-vpls-sig)#vpls-peer 2.2.2.2	Configure VPLS Peers
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#service-template st1	Template configuration.
(config-svc)#match outer-vlan 20	Match criteria under template configuration
(config-svc)#exit	Exit service template mode.
(config)#service-template template4	Template configuration
(config-svc)#match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)#match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)#match untagged	Allow untagged traffic
(config-svc)#rewrite ingress push 300	Push Action performed for service template
(config-svc)#exit	Exit configure SVC mode
(config)#interface xe2	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.
(config-if)mpls-vpls v4 service-template st1	Associating the VPLS Instance to the attachment circuit interface to match service template st1.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

Validation

PE1

Verify VPLS Session:

```

PE1#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
SIG-Protocol: LDP
Attachment-Circuit :UP
Learning: Enabled
Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Tagged
Svlan Id: 0
Svlan Tpid: 8100
Configured interfaces:
  Interface: xe2
Service-template : s1
Match criteria : 10

Mesh Peers:
  2.2.2.2 (Up)

```

3.3.3.3 (Up)

```

Virtual Private LAN Service Instance: v4, ID: 28
SIG-Protocol: LDP
Attachment-Circuit :UP
Learning: Enabled
Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Tagged
Svlan Id: 0
Svlan Tpid: 8100
Configured interfaces:
  Interface: xe2
Service-template : template4
  Match criteria : 700
  1200/3200
  Untagged
  Action type : Push
  Action value : 300

```

```

Mesh Peers:
  2.2.2.2 (Up)
  3.3.3.3 (Up)

```

```
PE1#
```

Verify VPLS Mesh Peer:

```

PE1#show mpls vpls mesh
VPLS-ID      Peer Addr      Tunnel-Label  In-Label  Network-Intf  Out-
Label  Lkps/St  PW-INDEX  SIG-Protocol  Status  Ecmp-Group100
100      1      2.2.2.2      24320      Active  24322      xe2      24321      2/
Up      1      LDP      Active  N/A
100      1      3.3.3.3      24325      Active  24321      xe2      24323      2/
Up      1      LDP      Active  N/A
28      1      2.2.2.2      24327      Active  24324      xe2      24325      2/
Up      1      LDP      Active  N/A
28      1      3.3.3.3      24345      Active  24325      xe2      24324      2/
Up      1      LDP      Active  N/A

```

```
PE1#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe1	Passive	OPERATIONAL	30	00:22:12
3.3.3.3	xe1	Passive	OPERATIONAL	30	00:17:27
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:24:53

```
PE1#show ip ospf neighbor
```

```
Total number of full neighbors: 1
```

```
OSPF process 100 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
9.9.9.9	1	Full/Backup	00:00:37	10.10.1.2	xe1	0

```
p#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:03:07
2.2.2.2	xe2	Active	OPERATIONAL	30	00:25:52
3.3.3.3	xe3	Active	OPERATIONAL	30	00:03:09

```
p#show ip ospf neighbor
```

Total number of full neighbors: 3

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
1.1.1.1	1	Full/DR	00:00:30	10.10.1.1	xe1	0
2.2.2.2	1	Full/Backup	00:00:38	20.20.1.1	xe2	0
3.3.3.3	1	Full/Backup	00:00:37	30.30.1.1	xe3	0

PE2#show mpls vpls detail

Virtual Private LAN Service Instance: v4, ID: 28

SIG-Protocol: LDP

Attachment-Circuit :UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Tagged

Svlan Id: 0

Svlan Tpid: 8100

Configured interfaces:

Interface: xe2

Service-template : template4

Match criteria : 700,

Untagged ,

1200/3200

Action type : Push

Action value : 300

Mesh Peers:

1.1.1.1 (Up)

3.3.3.3 (Up)

Virtual Private LAN Service Instance: VPLS1, ID: 100

SIG-Protocol: LDP

Attachment-Circuit :UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Tagged

Svlan Id: 0

Svlan Tpid: 8100

Configured interfaces:

Interface: xe2

Service-template : st1

Match criteria : 10

Mesh Peers:

1.1.1.1 (Up)

3.3.3.3 (Up)

PE2#show mpls vpls mesh

(m) - Service mapped over multipath transport

(e) - Service mapped over LDP ECMP

VPLS-ID	Peer	Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX	SIG-Protocol	Status
---------	------	------	--------------	----------	--------------	-----------	---------	----------	--------------	--------

28	1.1.1.1	25601	26241	xe1	26240	2/Up	1	LDP	Active
28	3.3.3.3	25603	26242	xe1	27523	2/Up	2	LDP	Active
100	1.1.1.1	25601	26240	xe1	26241	2/Up	3	LDP	Active
100	3.3.3.3	25603	26243	xe1	27520	2/Up	4	LDP	Active

PE2#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:35:15
3.3.3.3	xe1	Passive	OPERATIONAL	30	00:30:51
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:00:59

PE2#show ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
9.9.9.9	1	Full/DR	00:00:32	20.20.1.2	xe1	0

PE3#show mpls vpls detail

Virtual Private LAN Service Instance: v4, ID: 28

SIG-Protocol: LDP

Attachment-Circuit :UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Tagged

Svlan Id: 0

Svlan Tpid: 8100

Configured interfaces:

Interface: xe2

Service-template : template4

Match criteria : 700,

Untagged ,

1200/3200

Action type : Push

Action value : 300

Mesh Peers:

1.1.1.1 (Up)

2.2.2.2 (Up)

Virtual Private LAN Service Instance: VPLS1, ID: 100

SIG-Protocol: LDP

Attachment-Circuit :UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500

Description: none

```

service-tpid: dot1.q
Operating mode: Tagged
Svlan Id: 0

```

```

Svlan Tpid: 8100
Configured interfaces:
Interface: xe2
Service-template : st1
Match criteria : 20

```

```

Mesh Peers:
1.1.1.1 (Up)
2.2.2.2 (Up)

```

```
PE3#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:02:23
1.1.1.1	xe1	Active	OPERATIONAL	30	00:31:56
2.2.2.2	xe1	Active	OPERATIONAL	30	00:32:17

```
PE3#show ip ospf neighbor
```

```
Total number of full neighbors: 1
```

```
OSPF process 100 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
9.9.9.9	1	Full/DR	00:00:37	30.30.1.2	xe1	0

Validation for the Number of Configured VPLS Instances

This example below shows number of configured VPLS instances.

```

PE1#show mpls vpls count
-----
Total VPLS instances      : 2
Active VPLS instances     : 2
Inactive VPLS instances  : 2
-----

```

The example below shows the Count of VPLS from LDP standpoint

```

PE1#show ldp vpls count
-----
Total VPLS instances      : 2
Active VPLS instances     : 2
Inactive VPLS instances  : 0
-----

```

The example below shows the number of MAC addresses learned by VPLS.

```

PE1#show mpls vpls mac-address count
Total no of MAC addresses learnt :6

```


VPLS Split Horizon Group

In VPLS Hierarchy, multiple attachment circuits (AC) can be configured per few VPLS instances and AC-AC traffic blocking is not supported. Thus, when the PE router receives a broadcast, multicast, or unknown unicast packet on an AC, it sends the packet out on all other attachment circuits to all other CE devices participating in that VPLS instance.

To avoid this problem of a packet looping in the provider core, the PE devices enforce a "split-horizon" principle for the VPLS instances. That means the traffic will not flood if AC1 and AC2 are in same split horizon group.

The examples show the minimum configuration required for enabling a VPLS Mesh peer between PE-1, PE-2 with split horizon group. In the below example PE-1 and PE-2 use split horizon groups where traffic can't be forwarded between the ACs if they are part of same access groups. But can send/receive from network ports.



Figure 3-15: Figure 8-15: VPLS Mesh Peers split horizon

Configuration With Service Template

PE1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 48.48.48.48/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe0	Specify the Interface to be configured.
(config-if)#ip address 40.40.40.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface

(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe19	Specify the Interface to be configured
(config-if)#ip address 57.57.57.6/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bring up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe20	Specify the Interface to be configured
(config-if)#ip address 52.52.52.5/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bring up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface
(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config)#is-type level-1	Configure instance as level-2-only routing.
(config)#metric-style wide	Configure the new style of metric type as wide.
(config)#mpls traffic-eng router-id 48.48.48.48	Configure MPLS-TE unique router-id TLV.
(config)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config)#capability cspf	Enable CSPF feature for ISIS instance.
(config)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config)#fast-reroute ti-lfa level-1 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L1 IPv4 prefixes learned
(config)#fast-reroute ti-lfa level-2 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L2 IPv4 prefixes learned
(config)#bfd all-interfaces	Enable BFD for all neighbors.
(config)#net 49.0000.0000.0001.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config)#router ldp	Enter router mode for LDP.
(config-router)#targeted-peer ipv4 45.45.45.45	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit	Exit config-router-targeted-peer mode
(config-router)#exit	Exit router configuration mode.
(config)#router bgp 65010	Define the routing process. The number 65010 specifies the AS number

(config-router)#bgp router-id 48.48.48.48	Assign a BGP router ID.
(config-router)#neighbor 45.45.45.45 remote-as 65010	Define the eBGP neighbor
(config-router)#neighbor 45.45.45.45 fall-over bfd multihop	Enabling BFD at BGP level for particular neighbor.
(config-router)#neighbor 45.45.45.45 update-source lo	Update the source for that particular neighbor as loopback interface
(config-router)#address-family ipv4 unicast	Enter into labeled-unicast address family
(config-router)#neighbor 45.45.45.45 activate	Activate the neighbor inside labeled-unicast address family
(config-router)#exit-address-family	Exit from address family IPv4 labeled unicast
(config-router)#address-family vpnv4 unicast	Enter into vpnv4 unicast address family
(config-router)#neighbor 45.45.45.45 activate	Activate the neighbor inside vpnv4 address family
(config-router)#exit-address-family	Exit from address family vpnv4
(config-router)#address-family ipv6 unicast	Enter into labeled-unicast address family
(config-router)#redistribute connected	Redistribute the connected routes.
(config-router)#exit-address-family	Exit from address family IPv6 labeled unicast
(config)#mpls vpls VPLS-PE1-PE2-600 600	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 45.45.45.45	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#mpls vpls VPLS-PE1-PE2-601 601	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 45.45.45.45	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#mpls vpls VPLS-PE1-PE2-602 602	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 45.45.45.45	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#service-template ST-VPLS-PE1-PE2-600	Template configuration
(config-svc)#exit	Exit service template mode
(config)#service-template ST-VPLS-PE1-PE2-601	Template configuration
(config-svc)#exit	Exit service template mode
(config)#service-template ST-VPLS-PE1-PE2-602	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe2	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.

(config-if)#mpls-vpls VPLS-PE1-PE2-600 service-template ST-VPLS-PE1-PE2-600	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#split-horizon group access1	Configuring split horizon group.
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls VPLS-PE1-PE2-601 service-template ST-VPLS-PE1-PE2-601	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#split-horizon group access1	Configuring split horizon group
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls VPLS-PE1-PE2-602 service-template ST-VPLS-PE1-PE2-602	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#split-horizon group access1	Configuring split horizon group
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config)#interface xe23	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.
(config-if)#mpls-vpls VPLS-PE1-PE2-600 service-template ST-VPLS-PE1-PE2-600	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#split-horizon group access1	Configuring split horizon group
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls VPLS-PE1-PE2-601 service-template ST-VPLS-PE1-PE2-601	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#split-horizon group access1	Configuring split horizon group
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls VPLS-PE1-PE2-602 service-template ST-VPLS-PE1-PE2-602	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#split-horizon group access1	Configuring split horizon group
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

P1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 18.18.18.18/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface ge6	Specify the interface to be configured.
(config-if)#ip address 60.60.60.2/24	Configure IP address for the interface.
(config-if)#label-switching	Enabling label switching capability on router
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface

(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the Interface to be configured
(config-if)#ip address 60.60.60.2/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively brining up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Enable LDP IS-IS synchronization
(config-if)#ip router isis ISIS-IGP	Configure the ISIS interface network type as point to point
(config-if)#enable-ldp ipv4	Enable IS-IS routing on an interface
(config-if)#exit	Enable IPv4 LDP configuration on interface
(config)#interface xe3	Exit interface mode.
(config-if)#ip address 80.80.80.1/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface.
(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config)#is-type level-1	Configure instance as level-2-only routing.
(config)#metric-style wide	Configure the new style of metric type as wide.
(config)#mpls traffic-eng router-id 18.18.18.18	Configure MPLS-TE unique router-id TLV.
(config)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config)#capability cspf	Enable CSPF feature for ISIS instance.
(config)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config)#fast-reroute ti-lfa level-1 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L1 IPv4 prefixes learned
(config)#fast-reroute ti-lfa level-2 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L2 IPv4 prefixes learned
(config)#fast-reroute ti-lfa level-2 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L2 IPv4 prefixes learned
(config)#bfd all-interfaces	Enable BFD for all neighbors.
(config)#net 49.0000.0000.0002.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#exit	Exit router mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

PE2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 45.45.45.45/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface to be configured.
(config-if)#ip address 60.60.60.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bring up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe4	Specify the Interface to be configured.
(config-if)#ip address 70.70.70.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bring up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe8	Specify the Interface to be configured.
(config-if)#ip address 57.57.57.7/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bring up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface
(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config)#is-type level-1	Configure instance as level-2-only routing.
(config)#metric-style wide	Configure the new style of metric type as wide.
(config)#mpls traffic-eng router-id 48.48.48.48	Configure MPLS-TE unique router-id TLV.
(config)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config)#capability cspf	Enable CSPF feature for ISIS instance.

(config)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config)#fast-reroute ti-lfa level-1 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L1 IPv4 prefixes learned
(config)#fast-reroute ti-lfa level-2 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L2 IPv4 prefixes learned
(config)#bfd all-interfaces	Enable BFD for all neighbors.
(config)#net 49.0000.0000.0003.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config)#router ldp	Enter router mode for LDP.
(config-router)#targeted-peer ipv4 48.48.48.48	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit	Exit config-router-targeted-peer mode
(config-router)#exit	Exit router configuration mode.
(config)#router bgp 65010	Define the routing process. The number 65010 specifies the AS number
(config-router)#bgp router-id 45.45.45.45	Assign a BGP router ID.
(config-router)#neighbor 48.48.48.48 remote-as 65010	Define the eBGP neighbor
(config-router)#neighbor 48.48.48.48 fall-over bfd multihop	Enabling BFD at BGP level for particular neighbor.
(config-router)#neighbor 48.48.48.48 update-source lo	Update the source for that particular neighbor as loopback interface
(config-router)#address-family ipv4 unicast	Enter into labeled-unicast address family
(config-router)#neighbor 48.48.48.48 activate	Activate the neighbor inside labeled-unicast address family
(config-router)#exit-address-family	Exit from address family IPv4 labeled unicast
(config-router)#address-family vpnv4 unicast	Enter into vpnv4 unicast address family
(config-router)#neighbor 48.48.48.48 activate	Activate the neighbor inside vpnv4 address family
(config-router)#exit-address-family	Exit from address family vpnv4
(config-router)#address-family ipv6 unicast	Enter into labeled-unicast address family
(config-router)#redistribute connected	Redistribute the connected routes.
(config-router)#exit-address-family	Exit from address family IPv6 labeled unicast
(config)#mpls vpls VPLS-PE1-PE2-600 600	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 48.48.48.48	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#mpls vpls VPLS-PE1-PE2-601 601	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 48.48.48.48	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.

(config)#mpls vpls VPLS-PE1-PE2-602 602	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 48.48.48.48	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#interface xe2.600 switchport	Creates a L2 sub-interface as xe2.600.
(config-if)#encapsulation dot1q 600	Configuring the attachment circuit interface as Layer-2.
(config-if)#rewrite push 0x8100 4050	Configure rewrite push.
(config-if)#split-horizon group access1	Configuring split horizon group.
(config-if-vpls)#load-interval 30	Configure load period in multiple of 30 seconds
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-if-vpls)#mpls-vpls VPLS-PE1-PE2-600	Associating the VPLS Instance to the attachment circuit interface.
(config)#interface xe2.601 switchport	Creates a L2 sub-interface as xe2.600.
(config-if)#encapsulation dot1q 601	Configuring the attachment circuit interface as Layer-2.
(config-if)#rewrite push 0x8100 4050	Configure rewrite push.
(config-if)#split-horizon group access1	Configuring split horizon group.
(config-if-vpls)#load-interval 30	Configure load period in multiple of 30 seconds
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-if-vpls)#mpls-vpls VPLS-PE1-PE2-601	Associating the VPLS Instance to the attachment circuit interface.
(config)#interface xe2.602 switchport	Creates a L2 sub-interface as xe2.600.
(config-if)#encapsulation dot1q 602	Configuring the attachment circuit interface as Layer-2.
(config-if)#rewrite push 0x8100 4050	Configure rewrite push.
(config-if)#split-horizon group access1	Configuring split horizon group.
(config-if-vpls)#load-interval 30	Configure load period in multiple of 30 seconds
(config-if)#access-if-vpls	Access VPLS under sub interface
config-if-vpls)#mpls-vpls VPLS-PE1-PE2-602	Associating the VPLS Instance to the attachment circuit interface.
(config)#interface xe23.600 switchport	Creates a L2 sub-interface as xe2.600.
(config-if)#encapsulation dot1q 600	Configuring the attachment circuit interface as Layer-2.
(config-if)#rewrite push 0x8100 4050	Configure rewrite push.
(config-if)#split-horizon group access1	Configuring split horizon group.
(config-if-vpls)#load-interval 30	Configure load period in multiple of 30 seconds
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-if-vpls)#mpls-vpls VPLS-PE1-PE2-600	Associating the VPLS Instance to the attachment circuit interface.
(config)#interface xe23.601 switchport	Creates a L2 sub-interface as xe2.600.
(config-if)#encapsulation dot1q 601	Configuring the attachment circuit interface as Layer-2.
(config-if)#rewrite push 0x8100 4050	Configure rewrite push.
(config-if)#split-horizon group access1	Configuring split horizon group.

(config-if-vpls)#load-interval 30	Configure load period in multiple of 30 seconds
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-if-vpls)#mpls-vpls VPLS-PE1-PE2-601	Associating the VPLS Instance to the attachment circuit interface.
(config)#interface xe23.602 switchport	Creates a L2 sub-interface as xe2.600.
(config-if)#encapsulation dot1q 602	Configuring the attachment circuit interface as Layer-2.
(config-if)#rewrite push 0x8100 4050	Configure rewrite push.
(config-if)#split-horizon group access1	Configuring split horizon group.
(config-if-vpls)#load-interval 30	Configure load period in multiple of 30 seconds
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-if-vpls)#mpls-vpls VPLS-PE1-PE2-602	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#commit	Commit the candidate configuration to the running configuration.
(config-if)#exit	Exit interface mode
#copy running-config startup-config	Save the configuration.

P2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 46.46.46.46/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface to be configured.
(config-if)#ip address 80.80.80.2/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 70.70.70.2/24	Specify the interface to be configured.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#ip address 40.40.40.2/24	Specify the interface to be configured.
(config-if)#label-switching	Enable label switching on the interface

(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface.
(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config)#is-type level-1	Configure instance as level-2-only routing.
(config)#metric-style wide	Configure the new style of metric type as wide.
(config)#mpls traffic-eng router-id 46.46.46.46	Configure MPLS-TE unique router-id TLV.
(config)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config)#capability cspf	Enable CSPF feature for ISIS instance.
(config)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config)#fast-reroute ti-lfa level-1 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L1 IPv4 prefixes learned
(config)#fast-reroute ti-lfa level-2 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L2 IPv4 prefixes learned
(config)#bfd all-interfaces	Enable BFD for all neighbors.
(config)#net 49.0000.0000.0004.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#exit	Exit router mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

VPLS - Per-Peer VPLS-type Signaling

Overview

Virtual Private LAN Service (VPLS) LDP signaling is a mechanism used to establish and manage pseudowires (PWs) in a VPLS network. VPLS allows geographically dispersed sites to share a common Ethernet broadcast domain, enabling any-to-any communication between the sites as if they were all connected to the same local area network (LAN).

VPLS LDP signaling occurs when each PE has discovered the endpoints of the VPLS instance. PWs are established over MPLS tunnels between VPN sites to transparently transmit Layer 2 packets. With the ability to configure the VPLS type per peer, and with the VPLS type configured being forwarded to LDP only when there is a change in the VPLS type at the VPLS instance or per peer level, signaling behavior is more efficient. Previously, the VPLS type at the VPLS instance was significant across all PEs involved in the VPLS instance.

If there is a change in the VPLS type at the VPLS instance or per peer level, NSM will update LDP, triggering LDP signaling. If there is no change, there is no need for re-signaling, and the VPLS session remains in the same state. The VPLS type configured on PEs at both ends of a pseudowire must match; otherwise, negotiation is required, and the VPLS session will be inactive until resolved.

Feature Characteristics

Provide the ability to configure the VPLS type on a per-peer basis, in addition to the VPLS type set across all PEs in the VPLS instance. The VPLS type configured on PEs at both ends of a pseudowire must match; otherwise, negotiation should occur. The per-peer VPLS type should take priority when both the VPLS instance type and the per-peer type are configured.

The examples show the minimum configuration required for enabling a VPLS Mesh peer between PE1, PE2, and PE3 in per peer VPLS-type Signaling.

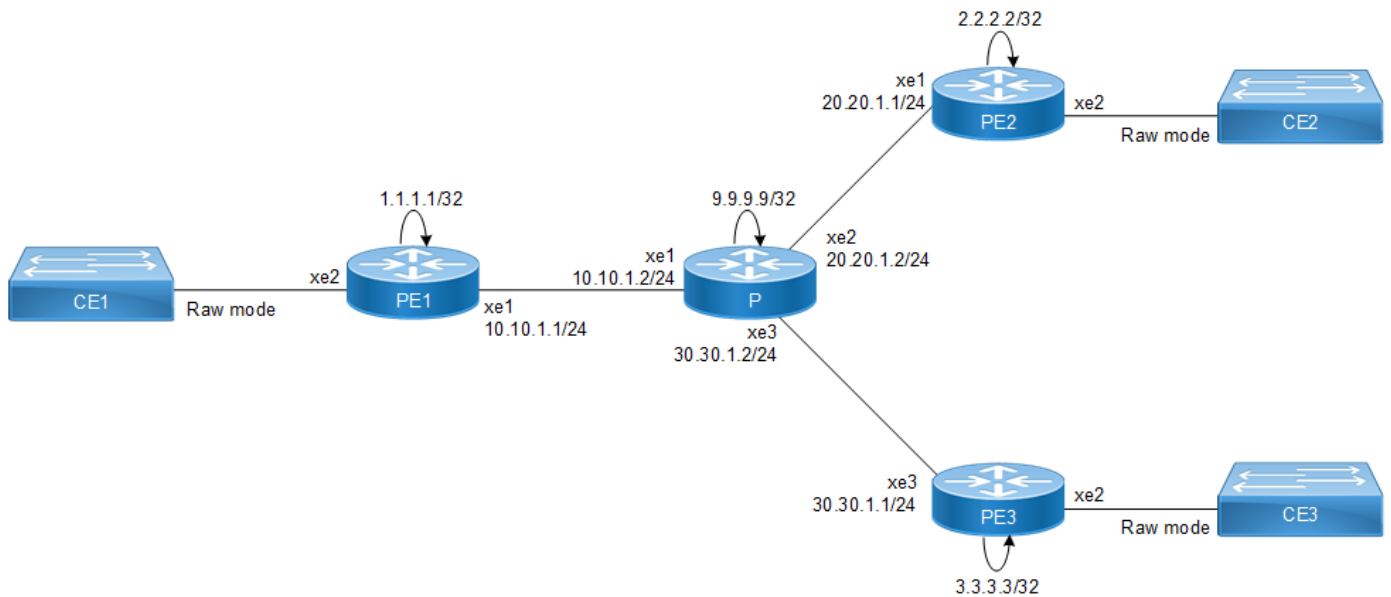


Figure 3-16: VPLS Per Peer VPLS Type Signaling

Configuration

The VPLS BGPSignaling feature enables you to use BGP as the control plane protocol for both auto discovery and signaling in accordance with RFC 4761

PE1 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
PE1(config)#configure terminal
PE1(config)#interface lo
PE1(config-if)#ip address 1.1.1.1/32 secondary
PE1(config-if)#exit
PE1(config)#interface xe1
PE1(config-if)#ip address 10.10.1.1/24
PE1(config-if)#no shutdown
PE1(config-if)#exit
PE1(config)#router ospf 100
PE1(config-router)#network 10.10.1.0/24 area 0
PE1(config-router)#network 1.1.1.1/32 area 0
PE1(config-router)#exit
PE1(config)#router ldp
PE1(config-router)# router-id 1.1.1.1
```

```

PE1(config-router)#transport-address ipv4 1.1.1.1
PE1(config-router)#targeted-peer ipv4 2.2.2.2
PE1(config-router-targeted-peer)#exit
PE1(config-router)#targeted-peer ipv4 3.3.3.3
PE1(config-router-targeted-peer)#exit
PE1(config-router)#exit
PE1(config)#interface xe1
PE1(config-if)#label-switching
PE1(config-if)#enable-ldp ipv4
PE1(config-if)#exit
PE1(config)#mpls vpls VPLS1 100
PE1(config-vpls)#signaling ldp
PE1(config-vpls-sig)#vpls-peer 2.2.2.2 vpls-type vlan
PE1(config-vpls-sig)#vpls-peer 3.3.3.3 vpls-type ethernet
PE1(config-vpls-sig)#exit-signaling
PE1(config-vpls)#exit
PE1(config)#service-template st1
PE1(config-svc)#exit
PE1(config)#interface xe2
PE1(config-if)#switchport
PE1(config-if)mpls-vpls VPLS1 service-template st1
PE1(config-if-vpls)#split-horizon group access1

```

2. To exit the configuration, execute the following command.

```

PE1(config-if-vpls)#exit
PE1(config-if)#exit

```

3. To save the configuration, execute the following command.

```

PE1(config)#commit
PE1(config)#copy running-config startup-config

```

P Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```

P(config)#configure terminal
P(config)#interface lo
P(config-if)#ip address 9.9.9.9/32 secondary
P(config-if)#exit
P(config)#interface xe1
P(config-if)#ip address 10.10.1.2/24
P(config-if)#exit
P(config)#interface xe2
P(config-if)#ip address 20.20.1.2/24
P(config-if)#exit
P(config)#interface xe3
P(config-if)#ip address 30.30.1.2/24
P(config-if)#exit
P(config)#router ospf 100
P(config-router)#network 10.10.1.0/24 area 0
P(config-router)#network 20.20.1.0/24 area 0
P(config-router)#network 30.30.1.0/24 area 0
P(config-router)#network 9.9.9.9/32 area 0

```

```
P(config-router)#exit
P(config)#router ldp
P(config-router)#router-id 9.9.9.9
P(config-router)#transport-address ipv4 9.9.9.9
P(config-router-targeted-peer)#exit
P(config-router)#exit
P(config)#interface xe1
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
P(config-if)#exit
P(config)#interface xe2
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
P(config-if)#exit
P(config)#interface xe3
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
```

2. To exit the configuration, execute the following command.

```
P(config-if)#exit
```

3. To save the configuration, execute the following command.

```
P(config)#commit
P(config)#copy running-config startup-config
```

PE2 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
PE2(config)#configure terminal
PE2(config)#interface lo
PE2(config-if)#ip address 2.2.2.2/32 secondary
PE2(config-if)#exit
PE2(config)#interface xe1
PE2(config-if)#ip address 20.20.1.1/24
PE2(config-if)#no shutdown
PE2(config-if)#exit
PE2(config)#router ospf 100
PE2(config-router)#network 20.20.1.0/24 area 0
PE2(config-router)#network 2.2.2.2/32 area 0
PE2(config-router)#exit
PE2(config)#router ldp
PE2(config-router)#router-id 2.2.2.2
PE2(config-router)#transport-address ipv4 2.2.2.2
PE2(config-router)#targeted-peer ipv4 1.1.1.1
PE2(config-router-targeted-peer)#exit
PE2(config-router)#targeted-peer ipv4 3.3.3.3
PE2(config-router-targeted-peer)#exit
PE2(config-router)#exit
PE2(config)#interface xe1
PE2(config-if)#label-switching
PE2(config-if)#enable-ldp ipv4
PE2(config-if)#exit
```

```
PE2(config)#mpls vpls VPLS1 100
PE2(config-vpls)#signaling ldp
PE2(config-vpls-sig)#vpls-peer 2.2.2.2 vpls-type vlan
PE2(config-vpls-sig)#vpls-peer 3.3.3.3 vpls-type ethernet
PE2(config-vpls-sig)#exit-signaling
PE2(config-vpls)#exit
PE2(config)#service-template st1
PE2(config-svc)#exit
PE2(config)#interface xe2
PE2(config-if)#switchport
PE2(config-if)mpls-vpls VPLS1 service-template st1
PE2(config-if-vpls)#split-horizon group access1
```

2. To exit the configuration, execute the following command.

```
PE2(config-if-vpls)#exit
PE2(config-if)#exit
```

3. To save the configuration, execute the following command.

```
PE2(config)#commit
PE2(config)#copy running-config startup-config
```

PE3 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
PE3(config)#configure terminal
PE3(config)#interface lo
PE3(config-if)#ip address 3.3.3.3/32 secondary
PE3(config-if)#exit
PE3(config)#interface xe1
PE3(config-if)#ip address 30.30.1.1/24
PE3(config-if)#no shutdown
PE3(config-if)#exit
PE3(config)#router ospf 100
PE3(config-router)#network 30.30.1.0/24 area 0
PE3(config-router)#network 3.3.3.3/32 area 0
PE3(config-router)#exit
PE3(config)#router ldp
PE3(config-router)#router-id 3.3.3.3
PE3(config-router)#transport-address ipv4 3.3.3.3
PE3(config-router)#targeted-peer ipv4 1.1.1.1
PE3(config-router-targeted-peer)#exit
PE3(config-router)#targeted-peer ipv4 2.2.2.2
PE3(config-router-targeted-peer)#exit
PE3(config-router)#exit
PE3(config)#interface xe1
PE3(config-if)#label-switching
PE3(config-if)#enable-ldp ipv4
PE3(config-if)#exit
PE3(config)#mpls vpls VPLS1 100
PE3(config-vpls)#signaling ldp
PE3(config-vpls-sig)#vpls-peer 2.2.2.2 vpls-type vlan
PE3(config-vpls-sig)#vpls-peer 3.3.3.3 vpls-type ethernet
```

```

PE3(config-vpls-sig)#exit-signaling
PE3(config-vpls)#exit
PE3(config)#service-template st1
PE3(config-svc)#exit
PE3(config)#interface xe2
PE3(config-if)#switchport
PE3(config-if)mpls-vpls VPLS1 service-template st1
PE3(config-if-vpls)#split-horizon group access1

```

2. To exit the configuration, execute the following command.

```

PE3(config-if-vpls)#exit
PE3(config-if)#exit

```

3. To save the configuration, execute the following command.

```

PE3(config)#commit
PE3(config)#copy running-config startup-config

```

Validation

Use this command to validate the Per peer VPLS-type signaling.

PE1 Validation

```

PE1#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
  SIG-Protocol: LDP
  Attachment-Circuit :UP
  Learning: Enabled
  Control-Word: Disabled
  Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
  Description: none
  service-tpid: dot1.q
  Operating mode: Raw
  Configured interfaces:
    Interface: xe2
  Service-template : st1
  Match criteria : Accept all

Mesh Peers:
  2.2.2.2 (Up)
  3.3.3.3 (Up)
PE1#
PE1#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
  SIG-Protocol: LDP
  Attachment-Circuit: UP
  Learning: Enabled
  Control-Word: Disabled
  Flow Label Status: Disabled, Direction: None, Static: No
  Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
  Description: none
  service-tpid: dot1.q

```

Operating mode: Raw

Configured interfaces:

Interface: xe0
Status: Up
Split-horizon group : access1
Service-template : st1
Match criteria : Accept all

Mesh Peers:

2.2.2.2 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:55:45)
3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:55:01)

PE1#show ldp vpls 100

VPLS Identifier : 100
Peer IP : 2.2.2.2
VC State : UP
VC Type : vlan
VC Label Sent : 26241
VC Label Received : 26241
Local MTU : 1500
Remote MTU : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:55:47

VPLS Identifier : 100
Peer IP : 3.3.3.3
VC State : UP
VC Type : ethernet
VC Label Sent : 26240
VC Label Received : 26241
Local MTU : 1500
Remote MTU : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:55:03

Verify VPLS Mesh Peer

PE1#show mpls vpls mesh

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St
PW-INDEX	SIG-Protocol	Status				
100	2.2.2.2	24325	24321	xe1	24321	2/Up 1
LDP	Active					
100	3.3.3.3	24322	24320	xe1	24321	2/Up 2
LDP	Active					

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe1	Passive	OPERATIONAL	30	00:32:21
3.3.3.3	xe1	Passive	OPERATIONAL	30	00:20:50
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:34:18

PE1#show ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.145	1	Full/Backup	00:00:35	10.10.1.2	xe1	0

P#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:40:04
2.2.2.2	xe2	Active	OPERATIONAL	30	00:38:22
3.3.3.3	xe3	Active	OPERATIONAL	30	00:25:57

P#show ip ospf neighbor

Total number of full neighbors: 3

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.142	1	Full/DR	00:00:34	10.10.1.1	xe1	0
10.12.49.144	1	Full/Backup	00:00:29	20.20.1.1	xe2	0
10.12.49.146	1	Full/Backup	00:00:36	30.30.1.1	xe3	0

P#show mpls vpls detail

P#show ldp vpls detail

PE2#show mpls vpls VPLS1

Virtual Private LAN Service Instance: VPLS1, ID: 100

SIG-Protocol: LDP

Attachment-Circuit: UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Raw

Configured interfaces:

Interface: xe14

Status: Up

Split-horizon group : access1

Service-template : st1

Match criteria : Accept all

Mesh Peers:

1.1.1.1 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:17:37)
3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:19:08)

PE2#show ldp vpls 100

VPLS Identifier : 100
Peer IP : 1.1.1.1
VC State : UP
VC Type : vlan
VC Label Sent : 26241
VC Label Received : 26241
Local MTU : 1500
Remote MTU : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:17:53

VPLS Identifier : 100
Peer IP : 3.3.3.3
VC State : UP
VC Type : ethernet
VC Label Sent : 26240
VC Label Received : 26240
Local MTU : 1500
Remote MTU : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:19:24

PE2#show mpls vpls mesh

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX
100	1.1.1.1	25601	26240	xe1	26240	2/Up	1
Active							LDP
100	3.3.3.3	25603	26241	xe1	26241	2/Up	2
Active							LDP

PE2#show ldp session

Peer IP	Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1		xe1	Active	OPERATIONAL	30	00:41:59
3.3.3.3		xe1	Passive	OPERATIONAL	30	00:30:15
9.9.9.9		xe1	Passive	OPERATIONAL	30	00:42:14

PE2#show ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.145	1	Full/DR	00:00:35	20.20.1.2	xe1	0

```
PE3#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:44:25
2.2.2.2	xe1	Active	OPERATIONAL	30	00:44:13
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:43:47

```
PE3#show ip ospf neighbor
```

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.145	1	Full/DR	00:00:33	30.30.1.2	xe1	0

```
PE3#show mpls vpls detail
```

Virtual Private LAN Service Instance: VPLS1, ID: 100

SIG-Protocol: LDP

Attachment-Circuit :UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Raw

Configured interfaces:

Interface: xe2

Service-template : st1

Match criteria : Accept all

Mesh Peers:

1.1.1.1 (Up)

2.2.2.2 (Up)

```
PE3#show mpls vpls VPLS1
```

Virtual Private LAN Service Instance: VPLS1, ID: 100

SIG-Protocol: LDP

Attachment-Circuit: UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Raw

Configured interfaces:

Interface: xe3

Status: Up

Split-horizon group : access1

Service-template : st1

Match criteria : Accept all

Mesh Peers:

1.1.1.1 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:16:54)
2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:19:09)

PE3#show ldp vpls 100

VPLS Identifier : 100
Peer IP : 1.1.1.1
VC State : UP
VC Type : ethernet
VC Label Sent : 26241
VC Label Received : 26240
Local MTU : 1500
Remote MTU : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:17:09

VPLS Identifier : 100
Peer IP : 2.2.2.2
VC State : UP
VC Type : ethernet
VC Label Sent : 26240
VC Label Received : 26240
Local MTU : 1500
Remote MTU : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:19:24

PE3#show mpls vpls mesh

(m) - Service mapped over multipath transport

(e) - Service mapped over LDP ECMP

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX
100	1.1.1.1	25602	26240	xe1	26241	2/Up	LDP
Active							
100	2.2.2.2	25603	26241	xe1	26241	2/Up	LDP
Active							

VPLS - Tunnel-ID

Overview

Virtual Private LAN Service (VPLS) is a Layer 2 VPN technology that allows geographically dispersed sites to share an Ethernet broadcast domain by connecting them through a service provider's MPLS network. This effectively creates a single, bridged Ethernet LAN across multiple sites.

VPLS with Tunnel-IDs provides a robust solution for extending Ethernet LAN services over a wide area network. The use of Tunnel-IDs ensures efficient and reliable delivery of Ethernet frames across the MPLS core, enabling service providers to offer high-quality, scalable, and flexible VPN services to their customers.

Feature Characteristics

Tunnel-IDs in VPLS are essential for efficient and reliable operation due to their unique identification, support for scalability, dynamic allocation by protocols like LDP or BGP, and compatibility with various signaling methods. They enable precise traffic engineering and load balancing, enhance resilience through fast reroute mechanisms and redundancy, and improve security with traffic isolation and access control. Additionally, Tunnel-IDs facilitate network management and monitoring by providing visibility into network paths and performance metrics, and they ensure compatibility with existing infrastructure for seamless integration of new services.

The examples show the minimum configuration required for enabling a VPLS Tunnel-ID between PE1, PE2, and PE3.

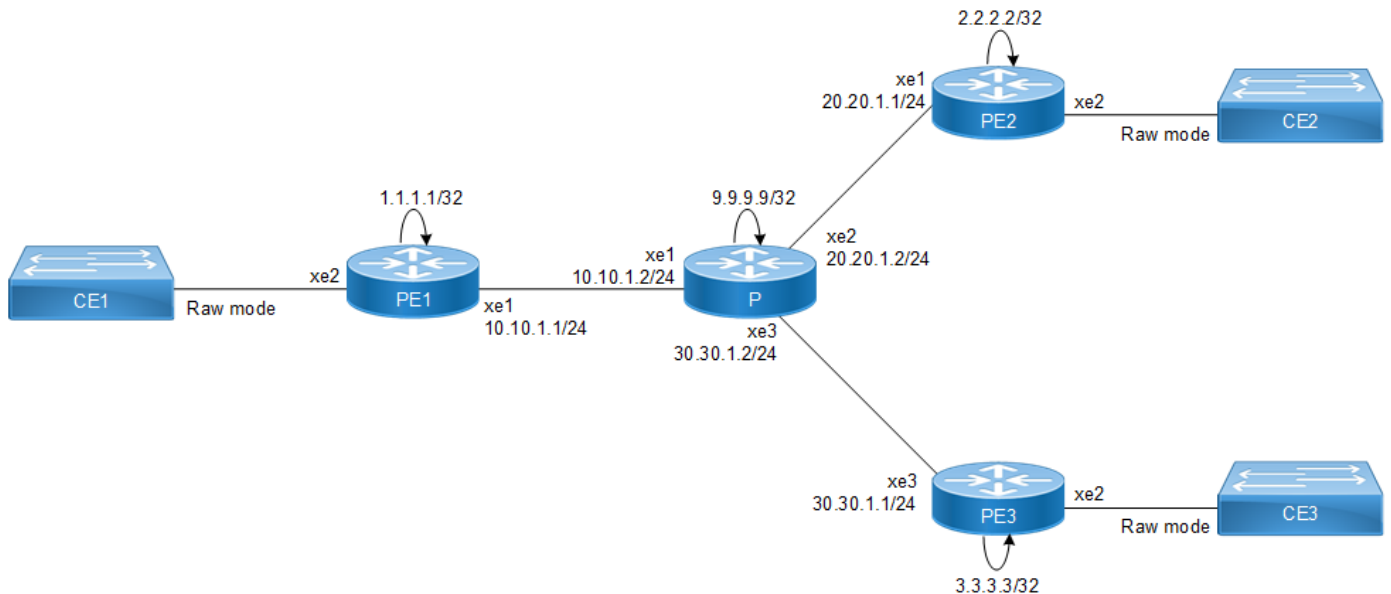


Figure 3-17: VPLS Tunnel-ID

Configuration

The VPLS Tunnel-ID feature enables you to use BGP as the control plane protocol for both auto discovery and signaling in accordance with RFC 4761

PE1 Configuration

1. To enable the VPLS-Tunnel-ID, execute the following command in the config mode

```
PE1(config)#configure terminal
```

```

PE1(config)#interface lo
PE1(config-if)#ip address 1.1.1.1/32 secondary
PE1(config-if)#exit
PE1(config)#interface xe1
PE1(config-if)#ip address 10.10.1.1/24
PE1(config-if)#no shutdown
PE1(config-if)#exit
PE1(config)#router ospf 100
PE1(config-router)#network 10.10.1.0/24 area 0
PE1(config-router)#network 1.1.1.1/32 area 0
PE1(config-router)#exit
PE1(config)#router ldp
PE1(config-router)# router-id 1.1.1.1
PE1(config-router)#transport-address ipv4 1.1.1.1
PE1(config-router)#targeted-peer ipv4 2.2.2.2
PE1(config-router-targeted-peer)#exit
PE1(config-router)#targeted-peer ipv4 3.3.3.3
PE1(config-router-targeted-peer)#exit
PE1(config-router)#exit
PE1(config)#interface xe1
PE1(config-if)#label-switching
PE1(config-if)#enable-ldp ipv4
PE1(config-if)#exit
PE1(config)#mpls vpls VPLS1 100
PE1(config-vpls)#signaling ldp
PE1(config-vpls-sig) #mpls ftn-entry tunnel-id 100 2.2.2.2/32 200 10.10.1.2 xe1
primary
PE1(config-vpls-sig) #mpls ftn-entry tunnel-id 300 3.3.3.3/32 400 10.10.1.2 xe1
primary
PE1(config-vpls-sig)#exit-signaling
PE1(config-vpls)#exit
PE1(config)#service-template st1
PE1(config-svc)#exit
PE1(config)#interface xe2
PE1(config-if)#switchport
PE1(config-if)mpls-vpls VPLS1 service-template st1
PE1(config-if-vpls)#split-horizon group access1

```

2. To exit the configuration, execute the following command.

```

PE1(config-if-vpls)#exit
PE1(config-if)#exit

```

3. To save the configuration, execute the following command.

```

PE1(config)#commit
PE1(config)#copy running-config startup-config

```

P Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```

P(config)#configure terminal
P(config)#interface lo
P(config-if)#ip address 9.9.9.9/32 secondary

```

```
P(config-if)#exit
P(config)#interface xe1
P(config-if)#ip address 10.10.1.2/24
P(config-if)#exit
P(config)#interface xe2
P(config-if)#ip address 20.20.1.2/24
P(config-if)#exit
P(config)#interface xe3
P(config-if)#ip address 30.30.1.2/24
P(config-if)#exit
P(config)#router ospf 100
P(config-router)#network 10.10.1.0/24 area 0
P(config-router)#network 20.20.1.0/24 area 0
P(config-router)#network 30.30.1.0/24 area 0
P(config-router)#network 9.9.9.9/32 area 0
P(config-router)#exit
P(config)#router ldp
P(config-router)#router-id 9.9.9.9
P(config-router)#transport-address ipv4 9.9.9.9
P(config-router-targeted-peer)#exit
P(config-router)#exit
P(config)#interface xe1
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
P(config-if)#exit
P(config)#interface xe2
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
P(config-if)#exit
P(config)#interface xe3
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
```

2. To exit the configuration, execute the following command.

```
P(config-if)#exit
```

3. To save the configuration, execute the following command.

```
P(config)#commit
P(config)#copy running-config startup-config
```

PE2 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
PE2(config)#configure terminal
PE2(config)#interface lo
PE2(config-if)#ip address 2.2.2.2/32 secondary
PE2(config-if)#exit
PE2(config)#interface xe1
PE2(config-if)#ip address 20.20.1.1/24
PE2(config-if)#no shutdown
PE2(config-if)#exit
PE2(config)#router ospf 100
```

```

PE2(config-router)#network 20.20.1.0/24 area 0
PE2(config-router)#network 2.2.2.2/32 area 0
PE2(config-router)#exit
PE2(config)#router ldp
PE2(config-router)#router-id 2.2.2.2
PE2(config-router)#transport-address ipv4 2.2.2.2
PE2(config-router)#targeted-peer ipv4 1.1.1.1
PE2(config-router-targeted-peer)#exit
PE2(config-router)#targeted-peer ipv4 3.3.3.3
PE2(config-router-targeted-peer)#exit
PE2(config-router)#exit
PE2(config)#interface xe1
PE2(config-if)#label-switching
PE2(config-if)#enable-ldp ipv4
PE2(config-if)#exit
PE2(config)#mpls vpls VPLS1 100
PE2(config-vpls)#signaling ldp
PE2(config-vpls-sig) #mpls ftn-entry tunnel-id 200 1.1.1.1/32 100 20.20.1.2 xe16
primary
PE2(config-vpls-sig)#exit-signaling
PE2(config-vpls)#exit
PE2(config)#service-template st1
PE2(config-svc)#exit
PE2(config)#interface xe2
PE2(config-if)#switchport
PE2(config-if)mpls-vpls VPLS1 service-template st1
PE2(config-if-vpls)#split-horizon group access1

```

2. To exit the configuration, execute the following command.

```

PE2(config-if-vpls)#exit
PE2(config-if)#exit

```

3. To save the configuration, execute the following command.

```

PE2(config)#commit
PE2(config)#copy running-config startup-config

```

PE3 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```

PE3(config)#configure terminal
PE3(config)#interface lo
PE3(config-if)#ip address 3.3.3.3/32 secondary
PE3(config-if)#exit
PE3(config)#interface xe1
PE3(config-if)#ip address 30.30.1.1/24
PE3(config-if)#no shutdown
PE3(config-if)#exit
PE3(config)#router ospf 100
PE3(config-router)#network 30.30.1.0/24 area 0
PE3(config-router)#network 3.3.3.3/32 area 0
PE3(config-router)#exit
PE3(config)#router ldp

```



```

PE3(config-router)#router-id 3.3.3.3
PE3(config-router)#transport-address ipv4 3.3.3.3
PE3(config-router)#targeted-peer ipv4 1.1.1.1
PE3(config-router-targeted-peer)#exit
PE3(config-router)#targeted-peer ipv4 2.2.2.2
PE3(config-router-targeted-peer)#exit
PE3(config-router)#exit
PE3(config)#interface xe1
PE3(config-if)#label-switching
PE3(config-if)#enable-ldp ipv4
PE3(config-if)#exit
PE3(config)#mpls vpls VPLS1 100
PE3(config-vpls)#signaling ldp
PE3(config-vpls-sig) #mpls ftn-entry tunnel-id 400 1.1.1.1/32 300 30.30.1.2 xe21
primary
PE3(config-vpls-sig)#exit-signaling
PE3(config-vpls)#exit
PE3(config)#service-template st1
PE3(config-svc)#exit
PE3(config)#interface xe2
PE3(config-if)#switchport
PE3(config-if)mpls-vpls VPLS1 service-template st1
PE3(config-if-vpls)#split-horizon group access1

```

2. To exit the configuration, execute the following command.

```

PE3(config-if-vpls)#exit
PE3(config-if)#exit

```

3. To save the configuration, execute the following command.

```

PE3(config)#commit
PE3(config)#copy running-config startup-config

```

Validation

Use this command to validate the Per peer VPLS-type signaling.

PE1 Validation

```

PE1#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
SIG-Protocol: LDP
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
  Interface: xe2
Service-template : st1
Match criteria : Accept all

```

Mesh Peers:

2.2.2.2 (Up)

3.3.3.3 (Up)

PE1#

PE1#show mpls vpls VPLS1

Virtual Private LAN Service Instance: VPLS1, ID: 100

SIG-Protocol: LDP

Attachment-Circuit: UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Raw

Configured interfaces:

Interface: xe0

Status: Up

Split-horizon group : access1

Service-template : st1

Match criteria : Accept all

Mesh Peers:

2.2.2.2 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:55:45)

3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:55:01)

PE1#show ldp vpls 100

VPLS Identifier : 100

Peer IP : 2.2.2.2

VC State : UP

VC Type : vlan

VC Label Sent : 26241

VC Label Received : 26241

Local MTU : 1500

Remote MTU : 1500

Local PW Status Capability : disabled

Remote PW Status Capability : disabled

Current PW Status TLV : disabled

LDP-VPLS Signaled Time : 00:55:47

VPLS Identifier : 100

Peer IP : 3.3.3.3

VC State : UP

VC Type : ethernet

VC Label Sent : 26240

VC Label Received : 26241

Local MTU : 1500

Remote MTU : 1500

Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:55:03

Verify VPLS Mesh Peer

PE1#show mpls vpls mesh

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St
PW-INDEX	SIG-Protocol	Status				
100	2.2.2.2	24325	24321	xe1	24321	2/Up
LDP	Active					1
100	3.3.3.3	24322	24320	xe1	24321	2/Up
LDP	Active					2

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe1	Passive	OPERATIONAL	30	00:32:21
3.3.3.3	xe1	Passive	OPERATIONAL	30	00:20:50
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:34:18

PE1#show ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.145	1	Full/Backup	00:00:35	10.10.1.2	xe1	0

PE1#show mpls vpls VPLS1

Virtual Private LAN Service Instance: VPLS1, ID: 100

SIG-Protocol: LDP

Attachment-Circuit: UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Raw

Configured interfaces:

Interface: xe0

Status: Up

Split-horizon group : access1

Service-template : st1

Match criteria : Accept all

Mesh Peers:

2.2.2.2 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 04:17:22)

Tunnel-Id: 100

3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:00:49)

Tunnel-Id: 300

PE1#

PE1#show ldp vpls 100

VPLS Identifier : 100
Peer IP : 2.2.2.2
VC State : UP
VC Type : vlan
VC Label Sent : 26240
VC Label Received : 26241
Local MTU : 1500
Remote MTU : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 04:17:33

VPLS Identifier : 100
Peer IP : 3.3.3.3
VC State : UP
VC Type : ethernet
VC Label Sent : 26241
VC Label Received : 26242
Local MTU : 1500
Remote MTU : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:01:01

PE1#

P#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:40:04
2.2.2.2	xe2	Active	OPERATIONAL	30	00:38:22
3.3.3.3	xe3	Active	OPERATIONAL	30	00:25:57

P#show ip ospf neighbor

Total number of full neighbors: 3

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.142	1	Full/DR	00:00:34	10.10.1.1	xe1	0
10.12.49.144	1	Full/Backup	00:00:29	20.20.1.1	xe2	0
10.12.49.146	1	Full/Backup	00:00:36	30.30.1.1	xe3	0

PE1#show running-config vpls

!

mpls vpls VPLS1 100

signaling ldp

vpls-peer 2.2.2.2 tunnel-id 100 vpls-type vlan

vpls-peer 3.3.3.3 tunnel-id 300 vpls-type ethernet

```
    exit-signaling
exit-vpls
!
!
interface xe0
 mpls-vpls VPLS1 service-template st1
    split-horizon group access1
!
PE1#
```

```
PE2#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
SIG-Protocol: LDP
Attachment-Circuit: UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
```

Configured interfaces:

```
Interface: xe14
Status: Up
Split-horizon group : access1
Service-template : st1
Match criteria : Accept all
```

Mesh Peers:

```
1.1.1.1 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:17:37)
3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:19:08)
```

```
PE2#show ldp vpls 100
VPLS Identifier      : 100
Peer IP              : 1.1.1.1
VC State             : UP
VC Type              : vlan
VC Label Sent        : 26241
VC Label Received    : 26241
Local MTU             : 1500
Remote MTU           : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:17:53

VPLS Identifier      : 100
Peer IP              : 3.3.3.3
VC State             : UP
```

```
VC Type           : ethernet
VC Label Sent      : 26240
VC Label Received  : 26240
Local MTU          : 1500
Remote MTU         : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:19:24
```

```
PE2#show mpls vpls mesh
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX
100	1.1.1.1	25601	26240	xe1	26240	2/Up	1
Active							LDP
100	3.3.3.3	25603	26241	xe1	26241	2/Up	2
Active							LDP

```
PE2#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:41:59
3.3.3.3	xe1	Passive	OPERATIONAL	30	00:30:15
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:42:14

```
PE2#show ip ospf neighbor
```

```
Total number of full neighbors: 1
```

```
OSPF process 100 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.145	1	Full/DR	00:00:35	20.20.1.2	xe1	0

```
PE2#show mpls vpls VPLS1
```

```
Virtual Private LAN Service Instance: VPLS1, ID: 100
```

```
SIG-Protocol: LDP
```

```
Attachment-Circuit: UP
```

```
Learning: Enabled
```

```
Control-Word: Disabled
```

```
Flow Label Status: Disabled, Direction: None, Static: No
```

```
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
```

```
Description: none
```

```
service-tpid: dot1.q
```

```
Operating mode: Raw
```

```
Configured interfaces:
```

```
Interface: xe14
```

```
Status: Up
```

```
Split-horizon group : access1
```

```
Service-template : st1
```

```
Match criteria : Accept all
```

```
Mesh Peers:
```

```
1.1.1.1 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 04:16:11)
```

Tunnel-Id: 200

PE2#

PE2#show ldp vpls 100

VPLS Identifier : 100
Peer IP : 1.1.1.1
VC State : UP
VC Type : vlan
VC Label Sent : 26241
VC Label Received : 26240
Local MTU : 1500
Remote MTU : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 04:17:55

PE2#

PE3#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:44:25
2.2.2.2	xe1	Active	OPERATIONAL	30	00:44:13
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:43:47

PE3#show ip ospf neighbor

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.145	1	Full/DR	00:00:33	30.30.1.2	xe1	0

PE2#show running-config vpls

```
!  
mpls vpls VPLS1 100  
  signaling ldp  
  vpls-peer 1.1.1.1 tunnel-id 200 vpls-type vlan  
  exit-signaling  
exit-vpls
```

!

!

```
interface xe14  
  mpls-vpls VPLS1 service-template st1  
  split-horizon group access1
```

!

PE2#

PE3#show mpls vpls detail

Virtual Private LAN Service Instance: VPLS1, ID: 100
SIG-Protocol: LDP

```
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
  Interface: xe2
Service-template : st1
Match criteria : Accept all
```

```
Mesh Peers:
  1.1.1.1 (Up)
  2.2.2.2 (Up)
```

```
PE3#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
SIG-Protocol: LDP
Attachment-Circuit: UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
```

```
Configured interfaces:
  Interface: xe3
    Status: Up
    Split-horizon group : access1
    Service-template : st1
    Match criteria : Accept all
```

```
Mesh Peers:
  1.1.1.1 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:16:54)
  2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:19:09)
```

```
PE3#show ldp vpls 100
VPLS Identifier      : 100
Peer IP              : 1.1.1.1
VC State             : UP
VC Type              : ethernet
VC Label Sent        : 26241
VC Label Received    : 26240
Local MTU            : 1500
Remote MTU           : 1500
```


Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time : 00:17:09

VPLS Identifier : 100
 Peer IP : 2.2.2.2
 VC State : UP
 VC Type : ethernet
 VC Label Sent : 26240
 VC Label Received : 26240
 Local MTU : 1500
 Remote MTU : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time : 00:19:24

PE3#show mpls vpls mesh

(m) - Service mapped over multipath transport

(e) - Service mapped over LDP ECMP

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX
100	1.1.1.1	25602	26240	xe1	26241	2/Up	1
Active							LDP
100	2.2.2.2	25603	26241	xe1	26241	2/Up	2
Active							LDP

PE3#show running-config vpls

!

mpls vpls VPLS1 100

signaling ldp

vpls-peer 1.1.1.1 tunnel-id 400 vpls-type ethernet

exit-signaling

exit-vpls

!

!

interface xe3

mpls-vpls VPLS1 service-template st1

split-horizon group access1

!

PE3#

PE3#show mpls vpls VPLS1

Virtual Private LAN Service Instance: VPLS1, ID: 100

SIG-Protocol: LDP

Attachment-Circuit: UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500

Description: none

```
service-tpid: dot1.q
Operating mode: Raw
```

Configured interfaces:

```
Interface: xe3
Status: Up
Split-horizon group : access1
Service-template : st1
Match criteria : Accept all
```

Mesh Peers:

```
1.1.1.1 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:00:05)
Tunnel-Id: 400
```

PE3#

PE3#show ldp vpls 100

```
VPLS Identifier      : 100
Peer IP              : 1.1.1.1
VC State             : UP
VC Type              : ethernet
VC Label Sent        : 26242
VC Label Received    : 26241
Local MTU            : 1500
Remote MTU           : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time  : 00:01:44
```

PE3#

VPLS - Tunnel-Name

Overview

Virtual Private LAN Service (VPLS) is a Layer 2 VPN technology that allows geographically dispersed sites to share a common Ethernet broadcast domain, functioning as if they were all connected to the same LAN. This setup enables any-to-any communication between sites, providing the appearance of a single, cohesive LAN across multiple locations.

VPLS - Tunnel-Name is a configuration element within a VPLS network that is used to identify and manage MPLS tunnels. When configuring a VPLS instance on a network device, the Tunnel-Name is assigned to each MPLS tunnel. This can typically be done in the device's CLI under the VPLS configuration mode.

The "VPLS - Tunnel-Name" is a vital element in the configuration and management of VPLS networks. By providing unique identifiers for MPLS tunnels, it enhances the organization, management, and troubleshooting of VPLS instances, ultimately leading to more efficient and reliable network operations.

Feature Characteristics

The VPLS - Tunnel-Name feature in a VPLS network enhances functionality, manageability, and efficiency by providing unique identification for MPLS tunnels, simplifying network management, and improving troubleshooting. It allows granular control over configurations and policies, supports scalability and future network expansions, enhances security through controlled access and traffic isolation, and ensures redundancy and reliability by managing backup tunnels effectively. Additionally, it streamlines operations and reduces configuration errors, making it an essential tool for maintaining robust and reliable VPLS networks.

The examples show the minimum configuration required for enabling a VPLS Tunnel-Name between PE1, PE2, and PE3.

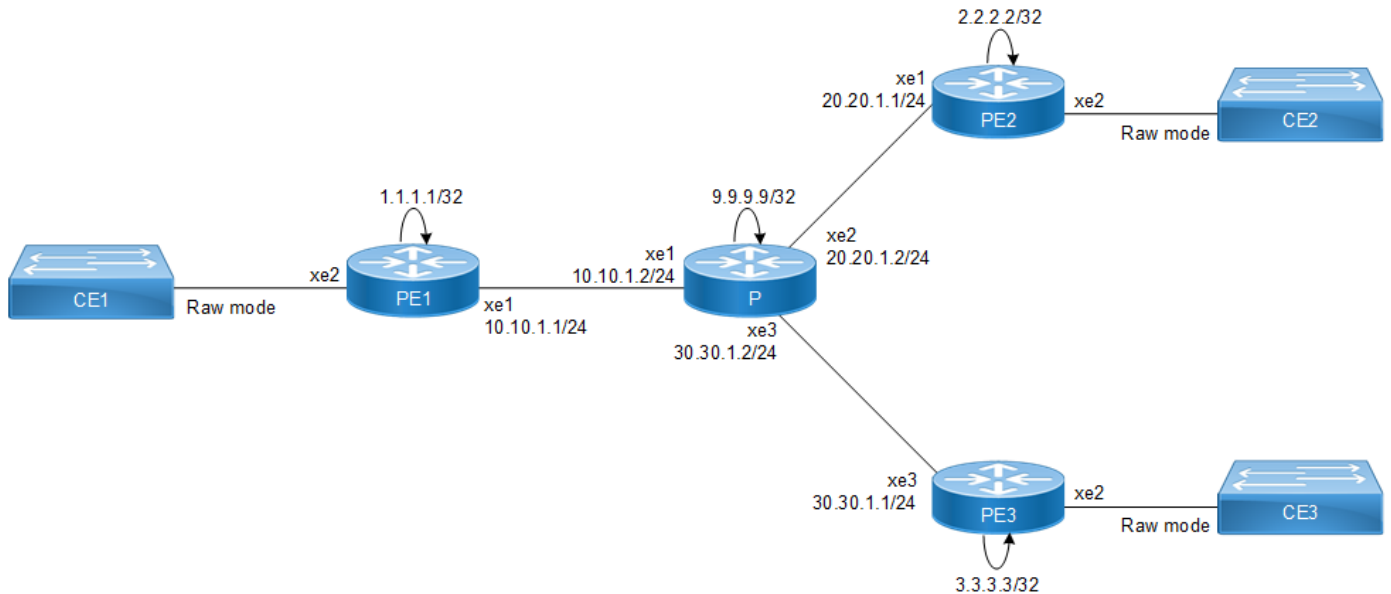


Figure 3-18: VPLS Tunnel-Name

Configuration

The VPLS Tunnel-Name feature enables you to use BGP as the control plane protocol for both auto discovery and signaling in accordance with RFC 4761

PE1 Configuration

1. To enable the per peer VPLS-Tunnel-Name, execute the following command in the config mode

```
PE1(config)#configure terminal
PE1(config)#interface lo
PE1(config-if)#ip address 1.1.1.1/32 secondary
PE1(config-if)#exit
PE1(config)#interface xe1
PE1(config-if)#ip address 10.10.1.1/24
PE1(config-if)#no shutdown
PE1(config-if)#exit
PE1(config)#router ospf 100
PE1(config-router)#network 10.10.1.0/24 area 0
PE1(config-router)#network 1.1.1.1/32 area 0
PE1(config-router)#exit
```

```

PE1(config)#router ldp
PE1(config-router)# router-id 1.1.1.1
PE1(config-router)#transport-address ipv4 1.1.1.1
PE1(config-router)#targeted-peer ipv4 2.2.2.2
PE1(config-router-targeted-peer)#exit
PE1(config-router)#targeted-peer ipv4 3.3.3.3
PE1(config-router-targeted-peer)#exit
PE1(config-router)#exit
PE1(config)#interface xe1
PE1(config-if)#label-switching
PE1(config-if)#enable-ldp ipv4
PE1(config-if)#exit
PE1(config)#mpls vpls VPLS1 100
PE1(config-vpls)#signaling ldp
PE1(config-vpls-sig)#vpls-peer 2.2.2.2 vpls-type vlan
PE1(config-vpls-sig)#vpls-peer 3.3.3.3 vpls-type ethernet
PE1(config-vpls-sig)#exit-signaling
PE1(config-vpls)#exit
PE1(config)#service-template st1
PE1(config-svc)#exit
PE1(config)#interface xe2
PE1(config-if)#switchport
PE1(config-if)mpls-vpls VPLS1 service-template st1
PE1(config-if-vpls)#split-horizon group access1

```

2. To exit the configuration, execute the following command.

```

PE1(config-if-vpls)#exit
PE1(config-if)#exit

```

3. To save the configuration, execute the following command.

```

PE1(config)#commit
PE1(config)#copy running-config startup-config

```

P Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```

P(config)#configure terminal
P(config)#interface lo
P(config-if)#ip address 9.9.9.9/32 secondary
P(config-if)#exit
P(config)#interface xe1
P(config-if)#ip address 10.10.1.2/24
P(config-if)#exit
P(config)#interface xe2
P(config-if)#ip address 20.20.1.2/24
P(config-if)#exit
P(config)#interface xe3
P(config-if)#ip address 30.30.1.2/24
P(config-if)#exit
P(config)#router ospf 100
P(config-router)#network 10.10.1.0/24 area 0
P(config-router)#network 20.20.1.0/24 area 0

```

```
P(config-router)#network 30.30.1.0/24 area 0
P(config-router)#network 9.9.9.9/32 area 0
P(config-router)#exit
P(config)#router ldp
P(config-router)#router-id 9.9.9.9
P(config-router)#transport-address ipv4 9.9.9.9
P(config-router-targeted-peer)#exit
P(config-router)#exit
P(config)#interface xe1
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
P(config-if)#exit
P(config)#interface xe2
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
P(config-if)#exit
P(config)#interface xe3
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
```

2. To exit the configuration, execute the following command.

```
P(config-if)#exit
```

3. To save the configuration, execute the following command.

```
P(config)#commit
P(config)#copy running-config startup-config
```

PE2 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
PE2(config)#configure terminal
PE2(config)#interface lo
PE2(config-if)#ip address 2.2.2.2/32 secondary
PE2(config-if)#exit
PE2(config)#interface xe1
PE2(config-if)#ip address 20.20.1.1/24
PE2(config-if)#no shutdown
PE2(config-if)#exit
PE2(config)#router ospf 100
PE2(config-router)#network 20.20.1.0/24 area 0
PE2(config-router)#network 2.2.2.2/32 area 0
PE2(config-router)#exit
PE2(config)#router ldp
PE2(config-router)#router-id 2.2.2.2
PE2(config-router)#transport-address ipv4 2.2.2.2
PE2(config-router)#targeted-peer ipv4 1.1.1.1
PE2(config-router-targeted-peer)#exit
PE2(config-router)#targeted-peer ipv4 3.3.3.3
PE2(config-router-targeted-peer)#exit
PE2(config-router)#exit
PE2(config)#interface xe1
PE2(config-if)#label-switching
```

```
PE2(config-if)#enable-ldp ipv4
PE2(config-if)#exit
PE2(config)#mpls vpls VPLS1 100
PE2(config-vpls)#signaling ldp
PE2(config-vpls-sig)#vpls-peer 2.2.2.2 vpls-type vlan
PE2(config-vpls-sig)#vpls-peer 3.3.3.3 vpls-type ethernet
PE2(config-vpls-sig)#exit-signaling
PE2(config-vpls)#exit
PE2(config)#service-template st1
PE2(config-svc)#exit
PE2(config)#interface xe2
PE2(config-if)#switchport
PE2(config-if)mpls-vpls VPLS1 service-template st1
PE2(config-if-vpls)#split-horizon group access1
```

2. To exit the configuration, execute the following command.

```
PE2(config-if-vpls)#exit
PE2(config-if)#exit
```

3. To save the configuration, execute the following command.

```
PE2(config)#commit
PE2(config)#copy running-config startup-config
```

PE3 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
PE3(config)#configure terminal
PE3(config)#interface lo
PE3(config-if)#ip address 3.3.3.3/32 secondary
PE3(config-if)#exit
PE3(config)#interface xe1
PE3(config-if)#ip address 30.30.1.1/24
PE3(config-if)#no shutdown
PE3(config-if)#exit
PE3(config)#router ospf 100
PE3(config-router)#network 30.30.1.0/24 area 0
PE3(config-router)#network 3.3.3.3/32 area 0
PE3(config-router)#exit
PE3(config)#router ldp
PE3(config-router)#router-id 3.3.3.3
PE3(config-router)#transport-address ipv4 3.3.3.3
PE3(config-router)#targeted-peer ipv4 1.1.1.1
PE3(config-router-targeted-peer)#exit
PE3(config-router)#targeted-peer ipv4 2.2.2.2
PE3(config-router-targeted-peer)#exit
PE3(config-router)#exit
PE3(config)#interface xe1
PE3(config-if)#label-switching
PE3(config-if)#enable-ldp ipv4
PE3(config-if)#exit
PE3(config)#mpls vpls VPLS1 100
PE3(config-vpls)#signaling ldp
```

```

PE3(config-vpls-sig)#vpls-peer 2.2.2.2 vpls-type vlan
PE3(config-vpls-sig)#vpls-peer 3.3.3.3 vpls-type ethernet
PE3(config-vpls-sig)#exit-signaling
PE3(config-vpls)#exit
PE3(config)#service-template st1
PE3(config-svc)#exit
PE3(config)#interface xe2
PE3(config-if)#switchport
PE3(config-if)mpls-vpls VPLS1 service-template st1
PE3(config-if-vpls)#split-horizon group access1

```

2. To exit the configuration, execute the following command.

```

PE3(config-if-vpls)#exit
PE3(config-if)#exit

```

3. To save the configuration, execute the following command.

```

PE3(config)#commit
PE3(config)#copy running-config startup-config

```

Validation

Use this command to validate the Per peer VPLS-type signaling.

PE1 Validation

```

PE1#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
SIG-Protocol: LDP
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
  Interface: xe2
Service-template : st1
Match criteria : Accept all

Mesh Peers:
  2.2.2.2 (Up)
  3.3.3.3 (Up)
PE1#

PE1#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

```

Ingress RSVP:

To	From	Tun-ID	LSP-ID	Type	LSPName	
State Uptime	Rt Style	Labelin	Labelout			
2.2.2.2	1.1.1.1	5001	2203	PRI	PE1_to_PE2-Primary	UP
00:04:19 1 1 SE	-	27522				
3.3.3.3	1.1.1.1	5002	2201	PRI	PE1_to_PE3-Primary	UP
00:00:15 1 1 SE	-	27523				

Total 2 displayed, Up 2, Down 0.

Egress RSVP:

To	From	Tun-ID	LSP-ID	Type	LSPName	
State Uptime	Rt Style	Labelin	Labelout			
1.1.1.1	2.2.2.2	5001	2201	PRI	PE2_to_PE1-Primary	UP
00:05:38 1 1 SE	29440	-				
1.1.1.1	3.3.3.3	5001	2201	PRI	PE3_to_PE1-Primary	UP
00:00:25 1 1 SE	29441	-				

Total 2 displayed, Up 2, Down 0.

PE1#

PE1#show mpls vpls VPLS1

Virtual Private LAN Service Instance: VPLS1, ID: 100

SIG-Protocol: LDP

Attachment-Circuit: UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Raw

Configured interfaces:

Interface: xe0

Status: Up

Split-horizon group : access1

Service-template : st1

Match criteria : Accept all

Mesh Peers:

2.2.2.2 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:55:45)

3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:55:01)

PE1#show ldp vpls 100

VPLS Identifier : 100

Peer IP : 2.2.2.2

VC State : UP

VC Type : vlan

VC Label Sent : 26241

VC Label Received : 26241

Local MTU : 1500

Remote MTU : 1500

Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:55:47

VPLS Identifier : 100
Peer IP : 3.3.3.3
VC State : UP
VC Type : ethernet
VC Label Sent : 26240
VC Label Received : 26241
Local MTU : 1500
Remote MTU : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:55:03

PE1#show mpls vpls mesh

(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St
PW-INDEX	SIG-Protocol	Status	UpTime			
100	2.2.2.2	27522	26242	xe1	26244	2/Up
1	LDP	Active	00:02:14			
100	3.3.3.3	27523	26241	xe1	26242	2/Up
2	LDP	Active	00:00:52			

PE1#

PE1#

PE1#

PE1#show mpls vpls VPLS1

Virtual Private LAN Service Instance: VPLS1, ID: 100
SIG-Protocol: LDP
Attachment-Circuit: UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw

Configured interfaces:

Interface: xe0
Status: Up
Split-horizon group : access1
Service-template : st1
Match criteria : Accept all

Mesh Peers:

2.2.2.2 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:02:21)

```
Tunnel-Name: PE1_to_PE2
3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:00:59)
Tunnel-Name: PE1_to_PE3
```

PE1#

PE1#

PE1#show ldp vpls 100

```
VPLS Identifier      : 100
Peer IP              : 2.2.2.2
VC State             : UP
VC Type              : vlan
VC Label Sent        : 26242
VC Label Received    : 26243
Local MTU             : 1500
Remote MTU           : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:02:25
```

```
VPLS Identifier      : 100
Peer IP              : 3.3.3.3
VC State             : UP
VC Type              : ethernet
VC Label Sent        : 26241
VC Label Received    : 26242
Local MTU             : 1500
Remote MTU           : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:01:03
```

PE1#

Verify VPLS Mesh Peer

PE1#show mpls vpls mesh

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St
PW-INDEX	SIG-Protocol	Status				
100	2.2.2.2	24325	24321	xe1	24321	2/Up 1
LDP	Active					
100	3.3.3.3	24322	24320	xe1	24321	2/Up 2
LDP	Active					

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe1	Passive	OPERATIONAL	30	00:32:21
3.3.3.3	xe1	Passive	OPERATIONAL	30	00:20:50
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:34:18

```
PE1#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID Pri State Dead Time Address Interface Instance ID
10.12.49.145 1 Full/Backup 00:00:35 10.10.1.2 xe1 0
```

```
PE1#show running-config vpls
!
mpls vpls VPLS1 100
signaling ldp
 vpls-peer 2.2.2.2 tunnel-name PE1_to_PE2 vpls-type vlan
 vpls-peer 3.3.3.3 tunnel-name PE1_to_PE3 vpls-type ethernet
exit-signaling
exit-vpls
!
!
interface xe0
 mpls-vpls VPLS1 service-template st1
 split-horizon group access1
!
PE1#
```

```
PE2#show run rsvp
!
router rsvp
!
!
interface xe16
 enable-rsvp
!
!
!
rsvp-path PE2_to_PE1 mpls
 20.20.1.2 strict
 10.10.1.1 strict
!
!
!
rsvp-trunk PE2_to_PE1 ipv4
 primary path PE2_to_PE1
 to 1.1.1.1
!
!
PE2#
```

```
PE2#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
```

(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:

To	From	Tun-ID	LSP-ID	Type	LSPName	
State	Uptime	Rt	Style	Labelin	Labelout	
1.1.1.1	2.2.2.2	5001	2201	PRI	PE2_to_PE1-Primary	UP
00:06:36	1 1 SE	-	27520			

Total 1 displayed, Up 1, Down 0.

Egress RSVP:

To	From	Tun-ID	LSP-ID	Type	LSPName	
State	Uptime	Rt	Style	Labelin	Labelout	
2.2.2.2	1.1.1.1	5001	2203	PRI	PE1_to_PE2-Primary	UP
00:05:16	1 1 SE	28801	-			

Total 1 displayed, Up 1, Down 0.

PE2#

PE2#show running-config vpls

!

mpls vpls VPLS1 100

signaling ldp

vpls-peer 1.1.1.1 tunnel-name PE2_to_PE1 vpls-type vlan

exit-signaling

exit-vpls

!

!

interface xe14

mpls-vpls VPLS1 service-template st1

split-horizon group access1

!

PE2#

PE2#show mpls vpls mesh

(m) - Service mapped over multipath transport

(e) - Service mapped over LDP ECMP

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St
PW-INDEX	SIG-Protocol	Status	UpTime			
100	1.1.1.1	27520	26243	xe16	26242	2/Up
1	LDP	Active	00:03:24			

PE2#

PE2#

PE2#show mpls vpls VPLS1

Virtual Private LAN Service Instance: VPLS1, ID: 100

SIG-Protocol: LDP

Attachment-Circuit: UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Raw

Configured interfaces:

Interface: xe14
Status: Up
Split-horizon group : access1
Service-template : st1
Match criteria : Accept all

Mesh Peers:

1.1.1.1 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:03:30)
Tunnel-Name: PE2_to_PE1

PE2#show ldp vpls 100

VPLS Identifier : 100
Peer IP : 1.1.1.1
VC State : UP
VC Type : vlan
VC Label Sent : 26243
VC Label Received : 26242
Local MTU : 1500
Remote MTU : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:03:33

PE2#

PE2#show mpls vpls VPLS1

Virtual Private LAN Service Instance: VPLS1, ID: 100
SIG-Protocol: LDP
Attachment-Circuit: UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw

Configured interfaces:

Interface: xe14
Status: Up
Split-horizon group : access1
Service-template : st1
Match criteria : Accept all

Mesh Peers:

1.1.1.1 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:17:37)
3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:19:08)

```
PE2#show ldp vpls 100
```

```
VPLS Identifier      : 100
Peer IP              : 1.1.1.1
VC State             : UP
VC Type              : vlan
VC Label Sent        : 26241
VC Label Received    : 26241
Local MTU            : 1500
Remote MTU           : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:17:53
```

```
VPLS Identifier      : 100
Peer IP              : 3.3.3.3
VC State             : UP
VC Type              : ethernet
VC Label Sent        : 26240
VC Label Received    : 26240
Local MTU            : 1500
Remote MTU           : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:19:24
```

```
PE2#show mpls vpls mesh
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX
100	1.1.1.1	25601	26240	xe1	26240	2/Up	1
Active							LDP
100	3.3.3.3	25603	26241	xe1	26241	2/Up	2
Active							LDP

```
PE2#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:41:59
3.3.3.3	xe1	Passive	OPERATIONAL	30	00:30:15
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:42:14

```
PE2#show ip ospf neighbor
```

```
Total number of full neighbors: 1
```

```
OSPF process 100 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.145	1	Full/DR	00:00:35	20.20.1.2	xe1	0

```
PE3#show run rsvp
```

```
!
```

```
router rsvp
```

```

!
!
interface xe21
  enable-rsvp
!
!
!
rsvp-path PE3_to_PE1 mpls
  30.30.1.2 strict
  10.10.1.1 strict
!
!
!
rsvp-trunk PE3_to_PE1 ipv4
  primary path PE3_to_PE1
  to 1.1.1.1
!
!
PE3#
PE3#show running-config vpls
!
mpls vpls VPLS1 100
  signaling ldp
  vpls-peer 1.1.1.1 tunnel-name PE3_to_PE1 vpls-type ethernet
  exit-signaling
  exit-vpls
!
!
interface xe3
  mpls-vpls VPLS1 service-template st1
  split-horizon group access1
!

PE3#show rsvp session
Type   : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State  : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To      From      Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin Labelout
1.1.1.1   3.3.3.3     5001   2201    PRI    PE3_to_PE1-Primary      UP
00:01:38  1 1 SE      -      27521
Total 1 displayed, Up 1, Down 0.

Egress RSVP:
To      From      Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin Labelout

```

```
3.3.3.3      1.1.1.1      5002      2201      PRI      PE1_to_PE3-Primary      UP
00:01:28  1 1 SE      30080      -
Total 1 displayed, Up 1, Down 0.
```

```
PE3#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:44:25
2.2.2.2	xe1	Active	OPERATIONAL	30	00:44:13
9.9.9.9	xe1	Passive	OPERATIONAL	30	00:43:47

```
PE3#show ip ospf neighbor
```

```
Total number of full neighbors: 1
```

```
OSPF process 100 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.12.49.145	1	Full/DR	00:00:33	30.30.1.2	xe1	0

```
PE3#show mpls vpls detail
```

```
Virtual Private LAN Service Instance: VPLS1, ID: 100
```

```
SIG-Protocol: LDP
```

```
Attachment-Circuit :UP
```

```
Learning: Enabled
```

```
Control-Word: Disabled
```

```
Flow Label Status: Disabled, Direction: None, Static: No
```

```
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
```

```
Description: none
```

```
service-tpid: dot1.q
```

```
Operating mode: Raw
```

```
Configured interfaces:
```

```
Interface: xe2
```

```
Service-template : st1
```

```
Match criteria : Accept all
```

```
Mesh Peers:
```

```
1.1.1.1 (Up)
```

```
2.2.2.2 (Up)
```

```
PE3#show mpls vpls VPLS1
```

```
Virtual Private LAN Service Instance: VPLS1, ID: 100
```

```
SIG-Protocol: LDP
```

```
Attachment-Circuit: UP
```

```
Learning: Enabled
```

```
Control-Word: Disabled
```

```
Flow Label Status: Disabled, Direction: None, Static: No
```

```
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
```

```
Description: none
```

```
service-tpid: dot1.q
```

```
Operating mode: Raw
```

```
Configured interfaces:
```

```
Interface: xe3
```

```
Status: Up
```



```
Split-horizon group : access1
Service-template : st1
Match criteria : Accept all
```

Mesh Peers:

```
1.1.1.1 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:16:54)
2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:19:09)
```

PE3#show ldp vpls 100

```
VPLS Identifier      : 100
Peer IP              : 1.1.1.1
VC State             : UP
VC Type              : ethernet
VC Label Sent        : 26241
VC Label Received    : 26240
Local MTU             : 1500
Remote MTU           : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:17:09
```

```
VPLS Identifier      : 100
Peer IP              : 2.2.2.2
VC State             : UP
VC Type              : ethernet
VC Label Sent        : 26240
VC Label Received    : 26240
Local MTU             : 1500
Remote MTU           : 1500
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
LDP-VPLS Signaled Time : 00:19:24
```

PE3#show mpls vpls mesh

```
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St	PW-INDEX
100	1.1.1.1	25602	26240	xe1	26241	2/Up]
Active							LDP
100	2.2.2.2	25603	26241	xe1	26241	2/Up	2
Active							LDP

PE3#show mpls vpls mesh

```
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St
PW-INDEX	SIG-Protocol	Status	UpTime			
100	1.1.1.1	27521	26242	xe21	26241	2/Up
1	LDP	Active	00:01:40			

PE3#

PE3#show mpls vpls VPLS1

Virtual Private LAN Service Instance: VPLS1, ID: 100

SIG-Protocol: LDP

Attachment-Circuit: UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Raw

Configured interfaces:

Interface: xe3

Status: Up

Split-horizon group : access1

Service-template : st1

Match criteria : Accept all

Mesh Peers:

1.1.1.1 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:01:45)

Tunnel-Name: PE3_to_PE1

PE3#

PE3#show ldp vpls 100

VPLS Identifier : 100

Peer IP : 1.1.1.1

VC State : UP

VC Type : ethernet

VC Label Sent : 26242

VC Label Received : 26241

Local MTU : 1500

Remote MTU : 1500

Local PW Status Capability : disabled

Remote PW Status Capability : disabled

Current PW Status TLV : disabled

LDP-VPLS Signaled Time : 00:01:50

PE3#

CHAPTER 4 Static VPLS Configuration

This chapter includes step-by-step configurations for Static VPLS. It also contains an overview of the concepts of Static VPLS.

Overview

Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint-to-multipoint communication over IP-MPLS networks. It allows geographically-dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires. A set of Martini circuits is grouped by a common VPLS identifier to achieve this service objective.

A pseudowire (PW) consists of a pair of point-to-point, single-hop unidirectional LSPs in opposite directions, each identified by a PW label, also called a Virtual Connection (VC) label.

The Label Distribution Protocol (LDP) is used to signal constituent VCs, and the service provider may use either LDP or RSVP-TE or add static provisioning to set up LSP tunnels to transport data through virtual circuits.

The VPLS identifier is exchanged with the labels, so that both PWs can be linked and be associated with a particular VPLS instance.

Configure Static VPLS

In the following examples, VPLS (v1) is configured on PE-2 with Static VPLS-Peers PE-1 and PE-3 using static LSPs.

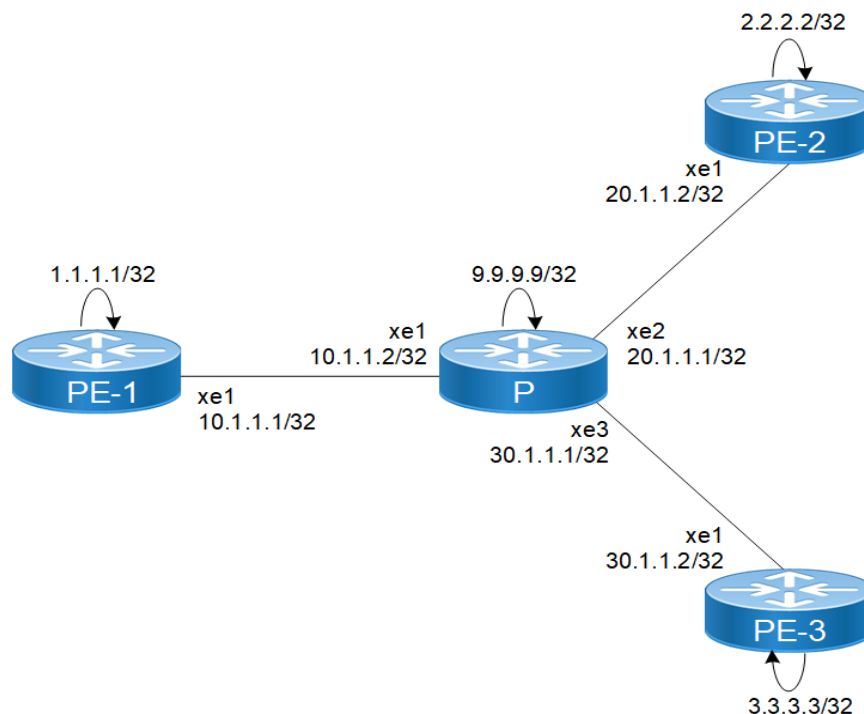


Figure 4-19: Static Virtual Private LAN Service Topology

PE-1

#configure terminal	Enter configure mode.
(config)#mpls ftn-entry tunnel-id 11 2.2.2.2/32 102 10.10.1.2 xe1 primary	Configure MPLS FTN entry for the creation of a static LSP to PE-2.
(config)#mpls ftn-entry tunnel-id 22 3.3.3.3/32 103 10.10.1.2 xe1 primary	Configure MPLS FTN entry for the creation of a static LSP to PE-3.
(config)#mpls ilm-entry 201 pop	Configure MPLS ILM entry for the creation of a static LSP to PE-2.
(config)#mpls ilm-entry 301 pop	Configure MPLS ILM entry for the creation of a static LSP to PE-3.
(config)#mpls vpls v1 100	Configure VPLS v1 with ID 100 on PE-1.
(config-vpls)#vpls-peer 2.2.2.2 tunnel-id 11 manual	Configure PE-2 as a manual VPLS peer using the static LSP tunnel ID 11
(config-vpls)#vpls-peer 3.3.3.3 tunnel-id 22 manual	Configure PE-3 as a manual VPLS peer using the static LSP tunnel ID 22.
(config-vpls)#exit	Exit Configure VPLS mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.10.1.1/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#exit	Exit interface mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#ospf router-id 1.1.1.1	Configure OSPF router id same as loopback IP address
(config-router)#transport-address ipv4 1.1.1.1	Configure transport address as loopback address.
(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#network 10.10.1.0/24 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#network 1.1.1.1/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#exit	Exit router mode
(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe2	Enter interface mode.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#mpls-vpls v1 service-template st1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit interface mode.

(config)#vpls fib-entry 100 peer 2.2.2.2 1000 xe1 2000	Configure VPLS FIB entry for VPLS peer PE-2.
(config)#vpls fib-entry 100 peer 3.3.3.3 3000 xe1 4000	Configure VPLS FIB entry for VPLS peer PE-3.
(config)#commit	Commit the transaction.

P

#configure terminal	Enter configure mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 9.9.9.9/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode
(config)#interface xe1	Specify the interface to be configured.
(config-if)#ip address 10.10.1.2/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode
(config-if)#ip address 20.20.1.2/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe3	Enter interface mode
(config-if)#ip address 30.30.1.2/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#ospf router-id 9.9.9.9	Configure OSPF router id same as loopback IP address
(config-router)#transport-address ipv4 9.9.9.9	Configure transport address as loopback address.
(config-router)#network 10.1.1.0/24 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the Interface address.
(config-router)#network 20.20.1.0/24 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the Interface address.
(config-router)#network 30.30.1.0/24 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the Interface address.
(config-router)#network 9.9.9.9/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the Interface address.
(config)#commit	Commit the transaction.

PE-2

#configure terminal	Enter Configure mode
(config)#mpls ftn-entry tunnel-id 11 1.1.1.1/32 201 20.20.1.2 xe1 primary	Configure MPLS FTN entry for the creation of a static LSP to PE-1, and designate xe1 as primary.

(config)#mpls ftn-entry tunnel-id 33 3.3.3.3/32 301 20.20.1.2 xe1 primary	Configure MPLS FTN entry for the creation of a static LSP to PE-3, and designate xe1 as primary.
(config)#mpls ilm-entry 102 pop	Configure MPLS ILM entry for the creation of a static LSP to PE-1.
(config)#mpls ilm-entry 302 pop	Configure MPLS ILM entry for the creation of a static LSP to PE-3
(config)#mpls vpls v1 100	Configure VPLS v1 with ID 100 on PE-2.
(config-vpls)#vpls-peer 1.1.1.1 tunnel-id 11 manual	Configure PE-1 as a manual VPLS peer using static LSP tunnel ID
(config-vpls)#vpls-peer 3.3.3.3 tunnel-id 33 manual	Configure PE-3 as a manual VPLS peer using static LSP tunnel ID
(config-vpls)#exit	Exit Configure VPLS mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter interface mode
(config-if)#ip address 20.20.1.1/24	Configure IP address for the interface
(config-if)#label-switching	Configure label switching
(config-if)#exit	Exit interface mode
(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe2	Enter interface mode
(config-if)#switchport	Make port Layer-2
(config-if)#mpls-vpls v1 service-template st1	Bind the VPLS to the Access Interface
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit interface mode
(config)#vpls fib-entry 100 peer 1.1.1.1 2500 xe1 1500	Configure VPLS FIB entry for VPLS peer PE-1.
(config)#vpls fib-entry 100 peer 3.3.3.3 3500 xe1 4500	Configure VPLS FIB entry for VPLS peer PE-3.
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#ospf router-id 2.2.2.2	Configure OSPF router id same as loopback IP address
(config-router)#transport-address ipv4 2.2.2.2	Configure transport address as loopback address.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#network 20.20.1.0/24 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#network 2.2.2.2/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#exit	Exit router mode
(config)#commit	Commit the transaction.

PE-3

#configure terminal	Enter Configure mode
(config)#mpls ftn-entry tunnel-id 11 1.1.1.1/32 301 30.30.1.2 xe1 primary	Configure MPLS FTN entry for the creation of a static LSP to PE-1.
(config)#mpls ftn-entry tunnel-id 22 2.2.2.2/32 302 30.30.1.2 xe1 primary	Configure MPLS FTN entry for the creation of a static LSP to PE-2.
(config)#mpls ilm-entry 103 pop	Configure MPLS ILM entry for the creation of a static LSP to PE-1.
(config)#mpls ilm-entry 203 pop	Configure MPLS ILM entry for the creation of a static LSP to PE-2.
(config)#mpls vpls v1 100	Configure VPLS v1 with ID 100 on PE-3.
(config-vpls)#vpls-peer 1.1.1.1 tunnel-id 11 manual	Configure PE-1 as a manual VPLS peer using static LSP tunnel ID 11.
(config-vpls)#vpls-peer 2.2.2.2 tunnel-id 22 manual	Configure PE-2 as a manual VPLS peer using static LSP tunnel ID 22.
(config-vpls)#exit	Exit Configure VPLS mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter interface mode
(config-if)#ip address 30.30.1.1/24	Configure IP address for the interface
(config-if)#label-switching	Configure label switching
(config-if)#exit	Exit interface mode
(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe2	Enter interface mode
(config-if)#switchport	Switch to Layer-2 mode
(config-if)#mpls-vpls v1 service-template st1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit interface mode.
(config)#vpls fib-entry 100 peer 1.1.1.1 4000 xe1 3000	Configure VPLS FIB entry for VPLS peer PE-1.
(config)#vpls fib-entry 100 peer 2.2.2.2 4500 xe1 3500	Configure VPLS FIB entry for VPLS peer PE-2.
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#ospf router-id 3.3.3.3	Configure OSPF router id same as loopback IP address
(config-router)#transport-address ipv4 3.3.3.3	Configure transport address as loopback address.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode

(config-router)#network 30.30.1.0/24 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#network 3.3.3.3/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config)#commit	Commit the transaction.

Validation

Enter the commands listed in the sections below to confirm the configurations.

Verify VPLS Session on PE-1

```
#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 100
  SIG-Protocol: STATIC
  Attachment-Circuit :UP
  Learning: Enabled
  Control-Word: Disabled
  Group ID: 0, Configured MTU: 1500
  Description: none
  service-tpid: dot1.q
  Operating mode: Raw
  Configured interfaces:
    Interface: xe48
  Service-template : st1
  Match criteria : Accept all

Mesh Peers:
  2.2.2.2 (Up)
  Tunnel-Id: 11
  3.3.3.3 (Up)
  Tunnel-Id: 22
PE1#
```

Verify VPLS Peer

```
#show mpls vpls mesh
VPLS-ID   Peer Addr      Tunnel-Label  In-Label  Network-Intf  Out-Label  Lkps/St  PW-INDEX  SIG-Protocol  Status
100       2.2.2.2       102          1000      xe1           2000       2/Up     1         STATIC       Active
100       3.3.3.3       103          3000      xe1           4000       2/Up     2         STATIC       Active
PE1#
```

Remove Configurations

Follow these steps to remove VPLS peer and VPLS spoke FIB entries from router PE-2.

#configure terminal	Enter configure mode
(config)#no vpls fib-entry 100 peer 1.1.1.1	Remove VPLS FIB for VPLS peer PE-1.

(config)#no vpls fib-entry 100 peer 3.3.3.3	Remove VPLS FIB for VPLS peer PE-3.
(config)#exit	Exit Configure mode

CHAPTER 5 BGP-VPLS Configuration

This chapter contains configurations for VPLS with Border Gateway Protocol Signaling.

Overview

Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint-to-multipoint communication over IP/MPLS networks. It allows geographically-dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires. A set of Kompella circuits is grouped by a common VPLS identifier to achieve this service objective.

A Pseudowire (PW) consists of a pair of point-to-point, single-hop unidirectional LSPs in opposite directions, each identified by a PW label, also called a Virtual Connection (VC) label.

The Border Gateway Protocol (BGP) is used to signaling VCs and for auto-discovery of neighbors. A service provider may use either LDP or RSVP-TE or add static provisioning to set up LSP tunnels to transport data through virtual circuits.

The VPLS identifier is exchanged with the labels, so that both PWs can be linked and associated with a particular VPLS instance.

Note: In Inter-AS, OcNOS accepts information from any other AS but the same VPN-ID/VPLS-ID (*: VPLS-ID). OcNOS does not have explicit RD/RT (import/export) support for BGP VPLS. RD/RT are automatically generated based on the configured BGP AS number and VPN-ID/VPLS-ID as (AS-number: VPN-ID).

Topology

The diagram depicts the topology for the configuration examples that follow.

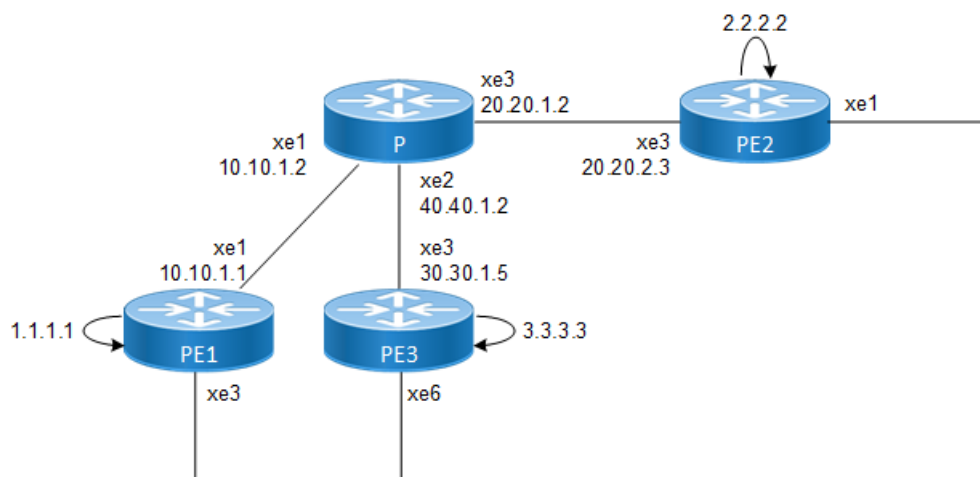


Figure 5-20: Sample Topology for VPLS with BGP Signaling

BGP-VPLS Configuration

PE-1

#configure terminal	Enter configuration mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.10.1.1/24	Set the IP address of the interface to 10.10.1.1/24.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback address.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
(config-if)#exit	Exit interface mode
(config)#mpls vpls v1 25	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (v1) and VPLS ID (25).
(config-vpls)#vpls-mtu 1400	Configure the MTU for the VPLS. (Default is 1500; range is <576 - 65535>).
(config-vpls)#signaling bgp	Enter the Signaling bgp mode for BGP VPLS.
(config-vpls-sig)#ve-id 1	Configure VE ID, which is mandatory for BGP VPLS, otherwise, Signaling does not take place. VE ID should be unique per VPLS instance.
(config-vpls-sig)#exit	Exit is a mandatory command for signaling BGP configuration to take affect. If exit is not given BGP signaling does not take place.
(config-vpls)#exit	Exit VPLS mode.
(config)#service-template v1	Configure service template
(config-svc)#match all	Configure the match condition
(config-svc)#exit	Exit interface mode
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#switchport	Switch to Layer-2 mode. (VPLS can be bound only on the Layer-2 port.)
(config-if)#mpls-vpls v1 service-template v1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#commit	Commit the transaction.

Note: VE IDs range is from 1 to 64. Administrator should configure the VE ID's accordingly in their Network.

PE1 - LDP

#configure terminal	Enter configuration mode
(config)#router ldp	Enter Router LDP mode.

(config-router)#router-id 1.1.1.1	Configure the router ID.
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address for a label space by binding the address to a loopback address.
(config-router)#exit	Exit Router mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config-if)#commit	Commit the transaction.

PE1 - OSPF

#configure terminal	Enter configure mode
(config)#router ospf 1	Configure the OSPF routing process, and specify the process ID.
(config-router)#network 10.10.1.0/24 area 0	Define the interfaces on which OSPF runs, and specify the backbone area 0.
(config-router)#network 1.1.1.1/32 area 0	
(config-router)#commit	Commit the transaction.

PE1 - BGP

#configure terminal	Enter configuration mode.
(config)#router bgp 100	Enter BGP Configure mode.
(config-router)#neighbor 2.2.2.2 remote-as 100	Configure PE2 as an iBGP peer.
(config-router)#neighbor 2.2.2.2 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#neighbor 3.3.3.3 remote-as 100	Configure PE3 as an iBGP peer.
(config-router)#neighbor 3.3.3.3 update-source lo	Update the source as loopback for iBGP peering with the remote PE3 router
(config-router)#address-family l2vpn vpls	Configure address-family L2VPN VPLS.
(config-router-af)#neighbor 2.2.2.2 activate	Activate PE2 in the VPLS address family.
(config-router-af)#neighbor 3.3.3.3 activate	Activate PE3 in the VPLS address family.
(config-router-af)#commit	Commit the transaction.

PE2

#configure terminal	Enter configuration mode.
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#ip address 20.20.1.3/24	Set the IP address of the interface to 20.20.1.3/24.
(config-if)#label-switching	Enable label switching on interface xe3.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback address.

(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if)#exit	Exit interface mode.
(config)#mpls vpls v1 25	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (v1) and VPLS ID (25).
(config-vpls)#vpls-mtu 1400	Configure the MTU for the VPLS. (Default is 1500; range is <576 - 65535>.)
(config-vpls)#signaling bgp	Enter the Signaling BGP mode for BGP VPLS.
(config-vpls-sig)#ve-id 2	Configure ve-id, which is mandatory for BGP VPLS. Without a ve-id Signaling does not take place. VE ID should be unique per VPLS instance.
(config-vpls-sig)#exit	Exit is a mandatory command for signaling BGP configuration to take affect. If exit is done, BGP signaling does not take place.
(config-vpls)#exit	Exit VPLS mode.
(config)#service-template v1	Configure service template
(config-svc)#match all	Configure the match condition
(config-svc)#exit	Exit interface mode
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#switchport	Switch to Layer-2 mode. (VPLS can only be bound on the Layer-2 port.)
(config-if)#mpls-vpls v1 service-template v1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#commit	Commit the transaction.

Note: VE ID's range is from 1 to 64. Administrator should configure the VE ID's accordingly in their Network.

PE2 - LDP

#configure terminal	Enter configuration mode
(config)#router ldp	Enter Router LDP mode.
(config-router)#router-id 2.2.2.2	Configure the router ID.
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address for a label space by binding the address to a loopback address.
(config-router)#exit	Exit Router mode.
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on the specified interface (xe3).
(config-if)#commit	Commit the transaction.

PE2 - OSPF

#configure terminal	Enter configuration mode.
(config)#router ospf 1	Configure the OSPF routing process, and specify the process ID.
(config-router)#network 20.20.1.0/24 area 0	Define the interfaces on which OSPF runs, and specify the backbone area 0.
(config-router)#network 2.2.2.2/32 area 0	
(config-router)#commit	Commit the transaction.

PE2 - BGP

#configure terminal	Enter configuration mode.
(config)#router bgp 100	Enter BGP router mode.
(config-router)#neighbor 1.1.1.1 remote-as 100	Configure PE1 as an iBGP peer.
(config-router)#neighbor 1.1.1.1 update-source lo	Update the source as loopback for iBGP peering with the remote PE1 router.
(config-router)#neighbor 3.3.3.3 remote-as 100	Configure PE3 as an iBGP peer.
(config-router)#neighbor 3.3.3.3 update-source lo	Update the source as loopback for iBGP peering with the remote PE3 router.
(config-router)#address-family l2vpn vpls	Configure address-family L2VPN VPLS.
(config-router-af)#neighbor 1.1.1.1 activate	Activate PE1 in the VPLS address family.
(config-router-af)#neighbor 3.3.3.3 activate	Activate PE3 in the VPLS address family.
(config-router-af)#commit	Commit the transaction.

PE3

#configure terminal	Enter configuration mode.
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#ip address 40.40.1.5/24	Set the IP address of the interface to 40.40.1.5/24.
(config-if)#label-switching	Enable label switching on interface xe3.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback address.
(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32.
(config-if)#exit	Exit interface mode.
(config)#mpls vpls v1 25	Create an instance of VPLS, and switch to the VPLS command mode, by indicating the VPLS name (v1) and VPLS ID (25).
(config-vpls)#vpls-mtu 1400	Configure the MTU for the VPLS. Default is 1500; range is <576 - 65535>.
(config-vpls)#signaling bgp	Enter the Signaling BGP mode, for BGP VPLS.

(config-vpls-sig)#ve-id 3	Configure ve-id, which is mandatory for BGP VPLS. Without a ve-id Signaling does not take place. VE ID should be unique per VPLS instance
(config-vpls-sig)#exit	Exit is a mandatory command for signaling BGP configuration to take affect. If exit is not done, BGP signaling does not take place.
(config-vpls)#exit	Exit VPLS mode.
(config)#service-template v1	Configure service template
(config-svc)#match all	Configure the match condition
(config-svc)#exit	Exit interface mode
(config)#interface xe6	Specify the interface (xe6) to be configured.
(config-if)#switchport	Switch to Layer-2 mode. (VPLS can be bound only on the Layer-2 port.)
(config-if)#mpls-vpls v1 service-template v1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#commit	Commit the transaction.

Note: VE ID's range is from 1 to 64. Administrator should configure the VE ID's accordingly in their Network.

PE3 - LDP

#configure terminal	Enter configuration mode.
(config)#router ldp	Enter Router LDP mode.
(config-router)#router-id 3.3.3.3	Configure the router ID.
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address for a label space by binding the address to a loopback address.
(config-router)#exit	Exit Router mode.
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#commit	Commit the transaction.

PE3 - OSPF

#configure terminal	Enter configuration mode.
(config)#router ospf 1	Configure the OSPF routing process, and specify the process ID.
(config-router)#network 40.40.1.0/24 area 0	Define the interfaces on which OSPF runs, and specify the backbone area 0.
(config-router)#network 3.3.3.3/32 area 0	
(config-router)#commit	Commit the transaction.

PE3 - BGP

#configure terminal	Enter configuration mode.
(config)#router bgp 100	Enter BGP Router mode.
(config-router)#neighbor 1.1.1.1 remote-as 100	Configure PE1 as an iBGP peer.
(config-router)#neighbor 1.1.1.1 update-source lo	Update the source as loopback for iBGP peering with the remote PE1 router.
(config-router)#neighbor 2.2.2.2 remote-as 100	Configure PE2 as an iBGP peer.
(config-router)#neighbor 2.2.2.2 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family l2vpn vpls	Configure address-family L2VPN VPLS.
(config-router-af)#neighbor 1.1.1.1 activate	Activate PE1 in the VPLS address family.
(config-router-af)#neighbor 2.2.2.2 activate	Activate PE2 in the VPLS address family.
(config-router-af)#commit	Commit the transaction.

P

#configure terminal	Enter configuration mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.10.1.2/24	Set the IP address of the interface to 10.10.1.2/24.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#ip address 40.40.1.2/24	Set the IP address of the interface to 40.40.1.2/24.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#ip address 20.20.1.2/24	Set the IP address of the loopback interface to 20.20.1.2/24.
(config-if)#label-switching	Enable label switching on interface xe3.
(config-if)#commit	Commit the transaction.

P - LDP

#configure terminal	Enter configuration mode.
(config)#router ldp	Enter Router LDP mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.

(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#commit	Commit the transaction.

P - OSPF

#configure terminal	Enter configuration mode.
(config)#router ospf 1	Configure the OSPF routing process, and specify the process ID.
(config-router)#network 10.10.1.0/24 area 0	Define the interfaces on which OSPF runs, and specify the backbone area 0.
(config-router)#network 20.20.1.0/24 area 0	
(config-router)#network 40.40.1.0/24 area 0	
(config-router)#commit	Commit the transaction.

Note: BGP L2VPN VPLS Route Reflector is not supported.

Validation

PE1

```
#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
SIG-Protocol: BGP
Route-Distinguisher :100:25
Route-Target :100:25
VE-ID :1
Attachment-Circuit :UP
Learning: Enabled
Group ID: 0, Configured MTU: 1400
Description: none
Redundancy admin role: Primary Redundancy oper role: Primary
Configured interfaces: Interface: xe3 oper-state UP Service-template
: v1 Match criteria : Accept all
```

```
Mesh Peers:
 2.2.2.2 (Up)
 3.3.3.3 (Up)
```

```
#show mpls vpls mesh
VPLS-ID Peer Addr Tunnel-Label In-Label Network-Intf Out-Label
Lkps/St PW-INDEX SIG-Protocol Status Ecmp-Group
25 2.2.2.2 3 24969 xe1 26125 2/Up
1298 BGP Active N/A
25 3.3.3.3 24677 24961 xe1 25605 2/Up
1297 BGP Active N/A
```

```
#show bgp l2vpn vpls detail
```

```

VPLS ID: 25
VE-ID: 1
Discovered Peers: 2
Route-Target: 1:100
Local RD: 2:100
Mesh Peers:
  Address:2.2.2.2, RD:2:100, VE-ID:2
  VC Details: VC-ID:610
  Remote (LB:26120,VBO:1,VBS:64)  Local (LB:24960,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:24969, Out Label:26125
  PW Status:Established
  VC Installed:Yes
All Local LB:
  LB:24960,VBO:1,VBS:64

  Address:3.3.3.3, RD:2:100, VE-ID:3
  VC Details: VC-ID:62
  Remote (LB:25600,VBO:1,VBS:64)  Local (LB:24960,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:24961, Out Label:25605
  PW Status:Established
  VC Installed:Yes

#show bgp l2vpn vpls 25
VPLS ID: 25
VE-ID: 1
Discovered Peers: 2
Route-Target: 1:100
Local RD: 2:100
Mesh Peers:
  Address:2.2.2.2, RD:2:100, VE-ID:2
  VC Details: VC-ID:610
  Remote (LB:26120,VBO:1,VBS:64)  Local (LB:24960,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:24969, Out Label:26125
  PW Status:Established
  VC Installed:Yes
All Local LB:
  LB:24960,VBO:1,VBS:64

  Address:3.3.3.3, RD:2:100, VE-ID:3
  VC Details: VC-ID:62
  Remote (LB:25600,VBO:1,VBS:64)  Local (LB:24960,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:24961, Out Label:25605
  PW Status:Established
  VC Installed:Yes

```

PE2

```

PE2#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label
Lkps/St	PW-INDEX	SIG-Protocol	Status		

25	1.1.1.1		25601	25600	xe3	25601
2/Up	1	BGP	Active			
25	3.3.3.3		25602	25602	xe3	25601
2/Up	2	BGP	Active			

PE2#show ldp sess

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
10.10.1.2	xe3	Passive	OPERATIONAL	30	00:15:54

PE2#show mpls vpls detail

Virtual Private LAN Service Instance: v1, ID: 25

SIG-Protocol: BGP

Route-Distinguisher :100:25

Route-Target :100:25

VE-ID :2

Attachment-Circuit :UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, Configured MTU: 1400

Description: none

service-tpid: dot1.q

Operating mode: Raw

Configured interfaces:

Interface: xe1

Service-template : v1

Match criteria : Accept all

Mesh Peers:

1.1.1.1 (Up)

3.3.3.3 (Up)

PE2#show bgp l2vpn vpls detail

VPLS ID: 25

VE-ID: 2

Discovered Peers: 2

Route-Target: 100:25

Local RD: 100:25

Mesh Peers:

BGP Peer:1.1.1.1/32

VC Nbr Address:1.1.1.1, RD:100:25, VE-ID:1

VC Details: VC-ID:21

Remote (LB:25600,VBO:1,VBS:64) Local (LB:25600,VBO:1,VBS:64)

LB sent on known VEID:Yes

In Label:25600, Out Label:25601

PW Status:Established

VC Installed:Yes

BGP Peer:3.3.3.3/32

VC Nbr Address:3.3.3.3, RD:100:25, VE-ID:3

VC Details: VC-ID:23

Remote (LB:25600,VBO:1,VBS:64) Local (LB:25600,VBO:1,VBS:64)

LB sent on known VEID:Yes

In Label:25602, Out Label:25601

```
PW Status:Established
VC Installed:Yes
```

```
PE2#show bgp l2vpn vpls 25
```

```
VPLS ID: 25
VE-ID: 2
Discovered Peers: 2
Route-Target: 100:25
Local RD: 100:25
Mesh Peers:
BGP Peer:1.1.1.1/32
  VC Nbr Address:1.1.1.1, RD:100:25, VE-ID:1
  VC Details: VC-ID:21
  Remote (LB:25600,VBO:1,VBS:64) Local (LB:25600,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25600, Out Label:25601
  PW Status:Established
  VC Installed:Yes

BGP Peer:3.3.3.3/32
  VC Nbr Address:3.3.3.3, RD:100:25, VE-ID:3
  VC Details: VC-ID:23
  Remote (LB:25600,VBO:1,VBS:64) Local (LB:25600,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25602, Out Label:25601
  PW Status:Established
  VC Installed:Yes
```

P

```
P#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
3.3.3.3	xe2	Active	OPERATIONAL	30	00:11:21
2.2.2.2	xe3	Active	OPERATIONAL	30	00:19:05
1.1.1.1	xe1	Active	OPERATIONAL	30	00:51:45

PE3

```
PE3#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
10.10.1.2	xe3	Passive	OPERATIONAL	30	00:12:27

```
PE3#show mpls vpls mesh
```

```
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label
Lkps/St	PW-INDEX SIG-Protocol	Status			
25	1.1.1.1	25604	25600	xe3	25602
2/Up	1	BGP	Active		
25	2.2.2.2	25605	25601	xe3	25602
2/Up	2	BGP	Active		

```
PE3#show mpls vpls detail
```

```
Virtual Private LAN Service Instance: v1, ID: 25
SIG-Protocol: BGP
Route-Distinguisher :100:25
Route-Target :100:25
```

```
VE-ID :3
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, Configured MTU: 1400
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
  Interface: xe6
Service-template : v1
Match criteria : Accept all
```

```
Mesh Peers:
  1.1.1.1 (Up)
  2.2.2.2 (Up)
```

```
PE3#show bgp l2vpn vpls detail
```

```
VPLS ID: 25
VE-ID: 3
Discovered Peers: 2
Route-Target: 100:25
Local RD: 100:25
Mesh Peers:
BGP Peer:1.1.1.1/32
  VC Nbr Address:1.1.1.1, RD:100:25, VE-ID:1
  VC Details: VC-ID:31
  Remote (LB:25600,VBO:1,VBS:64) Local (LB:25600,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25600, Out Label:25602
  PW Status:Established
  VC Installed:Yes
All Local LB:
  LB:25600,VBO:1,VBS:64

BGP Peer:2.2.2.2/32
  VC Nbr Address:2.2.2.2, RD:100:25, VE-ID:2
  VC Details: VC-ID:32
  Remote (LB:25600,VBO:1,VBS:64) Local (LB:25600,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25601, Out Label:25602
  PW Status:Established
  VC Installed:Yes
All Local LB:
  LB:25600,VBO:1,VBS:64
```

```
PE3#show bgp l2vpn vpls 25
```

```
VPLS ID: 25
VE-ID: 3
Discovered Peers: 2
Route-Target: 100:25
Local RD: 100:25
Mesh Peers:
```

BGP Peer:1.1.1.1/32
VC Nbr Address:1.1.1.1, RD:100:25, VE-ID:1
VC Details: VC-ID:31
Remote (LB:25600,VBO:1,VBS:64) Local (LB:25600,VBO:1,VBS:64)
LB sent on known VEID:Yes
In Label:25600, Out Label:25602
PW Status:Established
VC Installed:Yes
All Local LB:
LB:25600,VBO:1,VBS:64

BGP Peer:2.2.2.2/32
VC Nbr Address:2.2.2.2, RD:100:25, VE-ID:2
VC Details: VC-ID:32
Remote (LB:25600,VBO:1,VBS:64) Local (LB:25600,VBO:1,VBS:64)
LB sent on known VEID:Yes
In Label:25601, Out Label:25602
PW Status:Established
VC Installed:Yes
All Local LB:
LB:25600,VBO:1,VBS:64

CHAPTER 6 Static VPLS Service Mapping Configuration

Overview

This chapter includes step-by-step configurations for static VPLS. It also contains an overview of the concepts of Static VPLS. Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint-to-multipoint communication over IP- MPLS networks. It allows geographically-dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires.

Topology

The diagram depicts the topology for the configuration examples that follow.

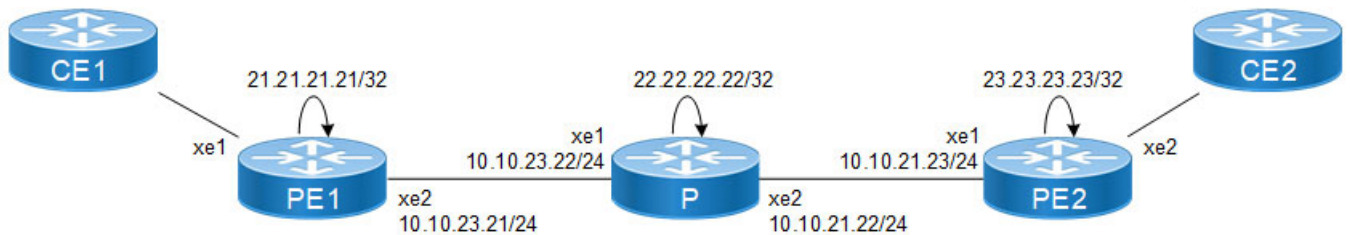


Figure 6-21: Static VPLS service mapping

Configuration

PE1: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter interface mode for the loopback interface.
(config-if)#ip address 21.21.21.21/32 secondary	Configure IP address on loopback interface.
(config-if)#commit	Commit the candidate configuration to the running configuration.
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 21.21.21.21	Set the router ID to IP address 21.21.21.21
(config-router)#transport-address ipv4 21.21.21.21	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 23.23.23.23	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode

PE1: Interface Configuration

(config)#interface xe2	Enter interface mode for xe2.
(config-if)#ip address 10.10.23.21/24	Configure IP address on the interface.
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on xe2
(config-if)#commit	Commit the candidate configuration to the running configuration.
(config-if)#exit	Exit interface mode

PE1: Static VPLS Configuration

(config)#mpls vpls v1 25	Enter VPLS configuration mode
(config-vpls)#vpls-peer 23.23.23.23 tunnel-id 1 manual	Configure VPLS peer
(config-vpls)#exit	Exit from VPLS configuration mode
(config)#mpls vpls v2 26	Enter VPLS configuration mode
(config-vpls)#vpls-peer 23.23.23.23 tunnel-id 1 manual	Configure VPLS peer
(config-vpls)#exit	Exit from VPLS configuration mode
(config)#mpls vpls v3 27	Enter VPLS configuration mode
(config-vpls)#vpls-peer 23.23.23.23 tunnel-id 1 manual	Configure VPLS peer
(config-vpls)#exit	Exit from VPLS configuration and configuration mode
(config)#mpls vpls v4 28	Enter VPLS configuration mode
(config-vpls)#vpls-peer 23.23.23.23 tunnel-id 1 manual	Configure VPLS peer
(config-vpls)#commit	Commit the candidate configuration to the running configuration.
(config-vpls)#end	Exit from VPLS configuration and configuration mode

PE1: FIB Entry Configuration

#configure terminal	Enter configuration mode.
(config)#mpls ftn-entry tunnel-id 1 23.23.23.23/32 100 10.10.23.22 xe2 primary	Configure Static LSP FTN entry
(config)#mpls ilm-entry 250 pop	Configure ILM entry
(config)#commit	Commit the candidate configuration to the running configuration.
(config)#exit	Exit

P: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter interface mode for the loopback interface.

(config-if)#ip address 22.22.22.22/32 secondary	Configure IP address on loopback interface.
(config-if)#commit	Commit the candidate configuration to the running configuration.
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 22.22.22.22	Set the router ID to IP address 22.22.22.22
(config-router)#transport-address ipv4 22.22.22.22	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit router mode

P: Interface Configuration

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#ip address 10.10.23.22/24	Configure IP address on the interface.
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#commit	Commit the candidate configuration to the running configuration.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode for xe2.
(config-if)#ip address 10.10.21.22/24	Configure IP address on the interface.
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#commit	Commit the candidate configuration to the running configuration.
(config-if)#exit	Exit interface mode

P: FIB Entry Configuration

#configure terminal	Enter configure mode.
(config)#mpls ilm-entry 100 swap 200 xe2 10.10.21.23 23.23.23.23/32	Configure Static LSP ILM entry
(config)#mpls ilm-entry 150 swap 250 xe1 10.10.23.21 21.21.21.21/32	Configure ILM entry
(config)#commit	Commit the candidate configuration to the running configuration.
(config)#exit	Exit

PE2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter interface mode for the loopback interface.
(config-if)#ip address 23.23.23.23/32 secondary	Configure IP address on loopback interface.

(config-if)#commit	Commit the candidate configuration to the running configuration.
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 23.23.23.23	Set the router ID to IP address 23.23.23.23
(config-router)#transport-address ipv4 23.23.23.23	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 21.21.21.21	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode

PE2: Interface Configuration

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#ip address 10.10.21.23/24	Configure IP address on the interface.
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#commit	Commit the candidate configuration to the running configuration.
(config-if)#exit	Exit interface mode

PE2: Static VPLS Configuration

(config)#mpls vpls v1 25	Enter VPLS configuration mode
(config-vpls)#vpls-peer 21.21.21.21 tunnel-id 1 manual	Configure VPLS peer
(config-vpls)#exit	Exit from VPLS configuration mode
(config)#mpls vpls v2 26	Enter VPLS configuration mode
(config-vpls)#vpls-peer 21.21.21.21 tunnel-id 1 manual	Configure VPLS peer
(config-vpls)#exit	Exit from VPLS configuration mode
(config)#mpls vpls v3 27	Enter VPLS configuration mode
(config-vpls)#vpls-peer 21.21.21.21 tunnel-id 1 manual	Configure VPLS peer
(config-vpls)#exit	Exit from VPLS configuration and configuration mode
(config)#mpls vpls v4 28	Enter VPLS configuration mode
(config-vpls)#vpls-peer 21.21.21.21 tunnel-id 1 manual	Configure VPLS peer
(config-vpls)#commit	Commit the candidate configuration to the running configuration.
(config-vpls)#exit	Exit from VPLS configuration and configuration mode

PE2: FIB Entry Configuration

(config)#mpls ftn-entry tunnel-id 1 21.21.21.21/32 150 10.10.21.22 xe1	Configure Static LSP FTN entry
(config)#mpls ilm-entry 200 pop	Configure ILM entry
(config)#commit	Commit the candidate configuration to the running configuration.
(config)#exit	Exit

Static VPLS Service Mapping Configuration**PE1: POP**

#configure terminal	Enter configuration mode.
(config)#service-template template1	Template configuration
(config-svc)#match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)#rewrite ingress pop outgoing- tpid dot1.q	Action to be performed for the match.
(config-svc)#commit	Commit the candidate configuration to the running configuration.
(config-svc)#exit	Exit template configuration mode

PE1: XLATE

(config)#service-template template2	Template configuration
(config-svc)#match double-tag outer-vlan 2030 inner-vlan 2024	Match criteria under template configuration
(config-svc)#rewrite ingress translate 2026 outgoing-tpid dot1.q	Action to be performed for the match
(config-svc)#commit	Commit the candidate configuration to the running configuration.
(config-svc)#exit	Exit template configuration mode

PE1: PUSH

(config)#service-template template3	Template configuration
(config-svc)#match outer-vlan 500	Match criteria under template configuration
(config-svc)#rewrite ingress push 300	Action to be performed for the default match .
(config-svc)#commit	Commit the candidate configuration to the running configuration.
(config-svc)#exit	Exit template configuration mode

PE1: PUSH-service-template with multiple match support

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config-svc)#commit	Commit the candidate configuration to the running configuration.
(config-svc)#exit	Exit configure SVC mode

PE1: Access port Configuration

(config)#interface xe1	Enter the Interface mode for ethernet1.
(config-if)#switchport	Configure interface as L2 interface
(config-if)#mpls-vpls v1 service-template template1	Configure template configuration.
(config_if_vpls)#exit	Exit Interface VPLS mode and return to Interface mode.
(config-if)#mpls-vpls v2 service-template template2	Configure template configuration.
(config_if_vpls)#exit	Exit Interface VPLS mode and return to Interface mode.
(config-if)#mpls-vpls v3 service-template template3	Configure template configuration.
(config_if_vpls)#exit	Exit Interface VPLS mode and return to Interface mode.
(config-if)#mpls-vpls v4 service-template template4	Configure template configuration.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config_if_vpls)#exit	Exit Interface mode and return to Configure mode.
(config-if)#exit	Exit interface mode.
(config)#vpls fib-entry 25 peer 23.23.23.23 1001 xe2 2001	Configure access port
(config)#vpls fib-entry 26 peer 23.23.23.23 1002 xe2 2002	Configure access port
(config)#vpls fib-entry 27 peer 23.23.23.23 1003 xe2 2003	Configure access port
(config)#vpls fib-entry 28 peer 23.23.23.23 1004 xe2 2004	Configure access port
(config)#commit	Commit the candidate configuration to the running configuration.

PE2: POP

#configure terminal	Configure mode
(config)#service-template template1	Template configuration
(config-svc)#match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)#rewrite ingress pop outgoing-tpid dot1.q	Action to be performed for the match.
(config-svc)#commit	Commit the candidate configuration to the running configuration.
(config-svc)#exit	Exit template configuration mode

PE2: XLATE

(config)#service-template template2	Template configuration
(config-svc)#match double-tag outer-vlan 2030 inner-vlan 2024	Match criteria under template configuration
(config-svc)#rewrite ingress translate 2026 outgoing-tpid dot1.q	Action to be performed for the match
(config-svc)#commit	Commit the candidate configuration to the running configuration.
(config-svc)#exit	Exit template configuration mode

PE2: PUSH

(config)#service-template template3	Template configuration
(config-svc)#match outer-vlan 500	Match criteria under template configuration
(config-svc)#rewrite ingress push 300	Action to be performed for the default match.
(config-svc)#commit	Commit the candidate configuration to the running configuration.
(config-svc)#exit	Exit template configuration mode

PE2: PUSH-service-template with multiple match

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config-svc)#commit	Commit the candidate configuration to the running configuration.
(config-svc)#exit	Exit configure SVC mode

PE2: Access port Configuration

(config)#interface xe2	Enter the Interface mode for ethernet2.
(config-if)#switchport	Configure interface as L2 interface
(config-if)#mpls-vpls v1 service-template template1	Configure template configuration.
(config-if-vpls)#exit	Exit Interface VPLS mode and return to Interface mode.
(config-if)#mpls-vpls v2 service-template template2	Configure template configuration.
(config-if-vpls)#exit	Exit Interface VPLS mode and return to Interface mode.
(config-if)#mpls-vpls v3 service-template template3	Configure template configuration.
(config-if-vpls)#exit	Exit Interface VPLS mode and return to Interface mode.
(config-if)#mpls-vpls v4 service-template template4	Configure template configuration.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit Interface VPLS mode and return to Interface mode.
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#vpls fib-entry 25 peer 21.21.21.21 2001 xe1 1001	Configure access port
(config)#vpls fib-entry 26 peer 21.21.21.21 2002 xe1 1002	Configure access port
(config)#vpls fib-entry 27 peer 21.21.21.21 2003 xe1 1003	Configure access port
(config)#vpls fib-entry 28 peer 21.21.21.21 2004 xe1 1004	Configure access port
(config)#commit	Commit the candidate configuration to the running configuration.

Validation

```
#show mpls vpls mesh
VPLS-ID      Peer Addr      Tunnel-Label  In-Label  Network-Intf  Out-Label
Lkps/St      PW-INDEX      SIG-Protocol  Status    Ecmp-Group
25           23.23.23.23    150          1001      xe2           2001
2/Up         1              STATIC       Active    N/A
26           23.23.23.23    150          1002      xe2           2002
2/Up         2              STATIC       Active    N/A
27           23.23.23.23    150          1003      xe2           2003
2/Up         3              STATIC       Active    N/A
28           23.23.23.23    150          1004      xe2           2004
2/Up         4              STATIC       Active    N/A
```

```
#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
SIG-Protocol: STATIC
Attachment-Circuit :UP
Learning: Enabled
Group ID: 0, Configured MTU: 1500
Description: none
```

```
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
  Interface: xel
Service-template : template1
Match criteria : 2024/2023
Action type : Pop
Outgoing tpid : dot1.q
```

```
Mesh Peers:
  23.23.23.23 (Up)
```

Virtual Private LAN Service Instance: v2, ID: 26

```
SIG-Protocol: STATIC
Attachment-Circuit :UP
Learning: Enabled
Group ID: 0, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
  Interface: xel
Service-template : template2
Match criteria : 2030/2024
Action type : Translate
Action value : 2026
Outgoing tpid : dot1.q
```

```
Mesh Peers:
  23.23.23.23 (Up)
```

Virtual Private LAN Service Instance: v3, ID: 27

```
SIG-Protocol: STATIC
Attachment-Circuit :UP
Learning: Enabled
Group ID: 0, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
  Interface: xel
Service-template : template3
Match criteria : Accept all
Action type : Push
Action value : 300
```

```
Mesh Peers:
  23.23.23.23 (Up)
```

Virtual Private LAN Service Instance: v4, ID: 28

```
SIG-Protocol: STATIC
Attachment-Circuit :UP
Learning: Enabled
Group ID: 0, Configured MTU: 1500
Description: none
```

```

service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
  Interface: xe1
Service-template : template4
  Match criteria : 700
1200/3200
Untagged
  Action type : Push
  Action value : 300

```

```

Mesh Peers:
  23.23.23.23 (Up)

```

```

PE2#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

```

VPLS-ID Lkps/St	Peer Addr PW-INDEX	SIG-Protocol	Tunnel-Label Status	In-Label	Network-Intf	Out-Label
25 2/Up	21.21.21.21 1	STATIC	150 Active	2001	xe10	1001
26 2/Up	21.21.21.21 2	STATIC	150 Active	2002	xe10	1002
27 2/Up	21.21.21.21 3	STATIC	150 Active	2003	xe10	1003
28 2/Up	21.21.21.21 4	STATIC	150 Active	2004	xe10	1004

```

PE2#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
  SIG-Protocol: STATIC
  Attachment-Circuit :UP
  Learning: Enabled
  Control-Word: Disabled
  Flow Label Status: Disabled, Direction: None, Static: No
  Group ID: 0, Configured MTU: 1500
  Description: none
  service-tpid: dot1.q
  Operating mode: Raw
  Configured interfaces:
    Interface: xe45
  Service-template : template1
  Match criteria : 2024/2023
  Action type : Pop
  Outgoing tpid : dot1.q

```

```

Mesh Peers:
  21.21.21.21 (Up)
  Tunnel-Id: 1

```

```

Virtual Private LAN Service Instance: v2, ID: 26
  SIG-Protocol: STATIC
  Attachment-Circuit :UP
  Learning: Enabled
  Control-Word: Disabled
  Flow Label Status: Disabled, Direction: None, Static: No

```


Group ID: 0, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
 Interface: xe45
Service-template : template2
 Match criteria : 2030/2024
 Action type : Translate
 Action value : 2026
 Outgoing tpid : dot1.q

Mesh Peers:
 21.21.21.21 (Up)
 Tunnel-Id: 1

Virtual Private LAN Service Instance: v3, ID: 27
SIG-Protocol: STATIC
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
 Interface: xe45
Service-template : template3
 Match criteria : 500
 Action type : Push
 Action value : 300

Mesh Peers:
 21.21.21.21 (Up)
 Tunnel-Id: 1

Virtual Private LAN Service Instance: v4, ID: 28
SIG-Protocol: STATIC
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
 Interface: xe45
Service-template : template4
 Match criteria : 700,
 Untagged ,
 1200/3200
 Action type : Push
 Action value : 300

Mesh Peers:
21.21.21.21 (Up)
Tunnel-Id: 1

PE2#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
22.22.22.22	xe10	Active	OPERATIONAL	30	00:29:22
21.21.21.21	xe10	Active	OPERATIONAL	30	00:29:26

PE2#

P1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
21.21.21.21	xe4	Active	OPERATIONAL	30	00:32:31
23.23.23.23	xe10	Passive	OPERATIONAL	30	00:31:47

CHAPTER 7 LDP-VPLS Service Mapping Configuration

Overview

This chapter includes step-by-step configurations for LDP VPLS. It also contains an overview of the concepts of LDP VPLS. Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint-to-multipoint communication over IP- MPLS networks. It allows geographically-dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires.

Topology

The diagram depicts the topology for the configuration examples that follow.

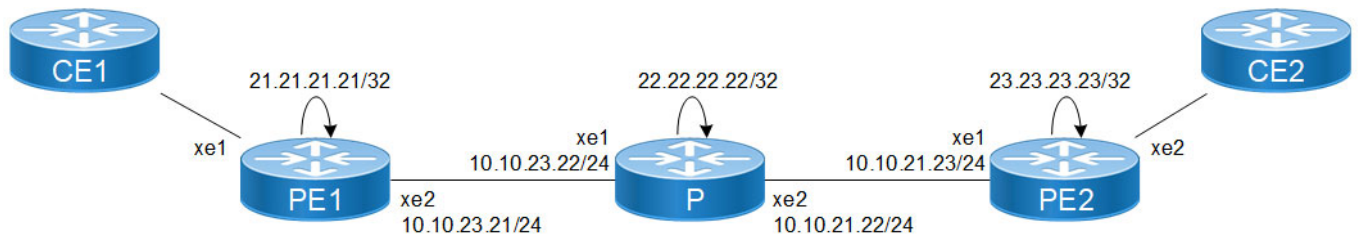


Figure 7-22: LDP-VPLS service mapping

Configuration

PE1: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 21.21.21.21/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

PE1: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 21.21.21.21	Set the router ID to IP address 21.21.21.21
(config-router)#transport-address ipv4 21.21.21.21	Configure transport address
(config-router)#targeted-peer ipv4 23.23.23.23	Configure targeted peer
(config-router)#targeted-peer #commit	Commit candidate configuration to the running configuration
(config-router-targeted-peer)#end	Exit from router target peer and LDP mode

PE1: Interface Configuration

#configure terminal	Enter configuration mode
(config)#interface xe2	Enter the Interface mode for xe2.
(config-if)# ip address 10.10.23.21/24	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

PE1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 21.21.21.21	Router-id configurations
(config-router)#network 21.21.21.21/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 10.10.23.0/24 area 0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.

PE1: LDP VPLS Configuration

(config)#mpls vpls v1 25	Enter VPLS config mode
(config-vpls)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 23.23.23.23	Configure VPLS Peer
(config-vpls-sig)#exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v2 26	Enter VPLS config mode
(config-vpls)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 23.23.23.23	Configure VPLS Peer
(config-vpls-sig)#exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v3 27	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 23.23.23.23	Configure VPLS Peer
(config-vpls-sig)# exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v4 28	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS

(config-vpls-sig)#vpls-peer 23.23.23.23	Configure VPLS Peer
(config-vpls-sig)# exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#commit	Commit candidate configuration to the running configuration

P: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 22.22.22.22/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

P: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 22.22.22.22	Set the router ID to IP address 22.22.22.22
(config-router)#transport-address ipv4 22.22.22.22	Configure transport address
(config-router)#commit	Commit candidate configuration to the running configuration
(config-router-targeted-peer)#end	Exit from router target peer and LDP mode

P: Interface Configuration

#configure terminal	Enter configuration mode
(config)#interface xe1	Enter the Interface mode for xe1.
(config-if)# ip address 10.10.23.22/24	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter the Interface mode for xe2.
(config-if)# ip address 10.10.21.22/24	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

P: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 22.22.22.22/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 10.10.23.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 10.10.21.0/24 area 0	Advertise network address in OSPF.

(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to the running configuration

PE2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 23.23.23.23/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

PE2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 23.23.23.23	Set the router ID to IP address 23.23.23.23
(config-router)#transport-address ipv4 23.23.23.23	Configure transport address
(config-router)#targeted-peer ipv4 21.21.21.21	Configure targeted peer
(config-router-targeted-peer)#commit	Commit candidate configuration to the running configuration
(config-router-targeted-peer)#end	Exit from router target peer and LDP mode

PE2: Interface Configuration

#configure terminal	Enter configuration mode.
(config)#interface xe1	Enter the Interface mode for xe1.
(config-if)# ip address 10.10.21.23/24	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

PE2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 23.23.23.23/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 10.10.21.0/24 area 0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.

PE2: LDP VPLS Configuration

(config)#mpls vpls v1 25	Enter VPLS config mode
(config-vpls)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling ldp	Define Signaling as LDP

(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 21.21.21.21	Configure VPLS Peer
(config-vpls-sig)# exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v2 26	Enter VPLS config mode
(config-vpls)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 21.21.21.21	Configure VPLS Peer
(config-vpls-sig)# exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v3 27	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 21.21.21.21	Configure VPLS Peer
(config-vpls-sig)# exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v4 28	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 21.21.21.21	Configure VPLS Peer
(config-vpls-sig)# exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#commit	Commit candidate configuration to the running configuration

LDP VPLS Service Mapping Configuration

PE1: POP

#configure terminal	Configure mode
(config)#service-template template1	Template configuration
(config-svc)# match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)# rewrite ingress pop outgoing-tpid dot1.q	Action to be performed for the match.
(config-svc)#exit	Exit template configuration mode

PE1: XLATE

(config)#service-template template2	Template configuration
(config-svc)# match double-tag outer-vlan 2030 inner-vlan 2024	Match criteria under template configuration
(config-svc)# rewrite ingress translate 2026 outgoing-tpid dot1.q	Action to be performed for the match
(config-svc)#exit	Exit template configuration mode

PE1: PUSH

(config)#service-template template3	Template configuration
(config-svc)# match outer-vlan 500	Match criteria under template configuration
(config-svc)# rewrite ingress push 300	Action to be performed for the default match.
(config-svc)#exit	Exit template configuration mode

PE1: PUSH-service-template with multiple match support

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config-svc)#exit	Exit configure SVC mode

PE1: Access port Configuration

(config)#interface xe1	Enter the Interface mode for xe1.
(config-if)#switchport	Configure interface as a layer 2 port.
(config-if)#mpls-vpls v1 service-template template1	Bind the VPLS to the Access Interface.
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v2 service-template template2	Bind the VPLS to the Access Interface.
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v3 service-template template3	Bind the VPLS to the Access Interface.
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v4 service-template template4	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode

(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#commit	Commit candidate configuration to the running configuration

PE2: POP

#configure terminal	Configure mode
(config)#service-template template1	Template configuration
(config-svc)# match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)# rewrite ingress pop outgoing-tpid dot1.q	Action to be performed for the match.
(config-svc)#exit	Exit template configuration mode

PE2: XLATE

(config)#service-template template2	Template configuration
(config-svc)# match double-tag outer-vlan 2030 inner-vlan 2024	Match criteria under template configuration
(config-svc)# rewrite ingress translate 2026 outgoing-tpid dot1.q	Action to be performed for the match
(config-svc)#exit	Exit template configuration mode

PE2: PUSH

(config)#service-template template3	Template configuration
(config-svc)# match outer-vlan 500	Match criteria under template configuration
(config-svc)# rewrite ingress push 300	Action to be performed for the default match.
(config-svc)#exit	Exit template configuration mode

PE2: PUSH-service-template with multiple match

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config-svc)#exit	Exit configure SVC mode

PE2: Access port Configuration

(config)#interface xe2	Enter the Interface mode for xe2.
(config-if)#switchport	Configure interface as a layer 2 port.
(config-if)#mpls-vpls v1 service-template template1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v2 service-template template2	Bind the VPLS to the Access Interface.
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v3 service-template template3	Bind the VPLS to the Access Interface.
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v4 service-template template4	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#commit	Commit candidate configuration to the running configuration

Validation

```
show mpls vpls mesh
VPLS-ID      Peer Addr      Tunnel-Label  In-Label  Network-Intf  Out-Label
Lkps/St      PW-INDEX SIG-Protocol Status      Ecmp-Group
25           23.23.23.23    24320        24322     xe2            24320
2/Up         1             LDP          Active     N/A
26           23.23.23.23    24320        24320     xe2            24321
2/Up         2             LDP          Active     N/A
27           23.23.23.23    24320        24321     xe2            24322
2/Up         3             LDP          Active     N/A
28           23.23.23.23    24320        24323     xe2            24324
2/Up         3             LDP          Active     N/A
```

```
#show ldp vpls
VPLS-ID      Peer Address      State  Type      Label-Sent  Label-Rcvd
25           23.23.23.23      Up     vlan      24322       24320
26           23.23.23.23      Up     vlan      24320       24321
27           23.23.23.23      Up     vlan      24321       24322
28           23.23.23.23      Up     vlan      24323       24324
```

```
#show ldp vpls detail
VPLS Identifier : 25
Peer IP         : 23.23.23.23
VC State        : UP
VC Type         : vlan
VC Label Sent   : 24322
VC Label Received : 24320
```

```
VPLS Identifier      : 26
Peer IP              : 23.23.23.23
VC State             : UP
VC Type              : vlan
VC Label Sent        : 24320
VC Label Received    : 24321
```

```
VPLS Identifier      : 27
Peer IP              : 23.23.23.23
VC State             : UP
VC Type              : vlan
VC Label Sent        : 24321
VC Label Received    : 24322
```

```
VPLS Identifier      : 28
Peer IP              : 23.23.23.23
VC State             : UP
VC Type              : vlan
VC Label Sent        : 24323
VC Label Received    : 24324
```

```
#show mpls vpls detail
```

```
Virtual Private LAN Service Instance: v1, ID: 25
```

```
SIG-Protocol: LDP
```

```
Attachment-Circuit :UP
```

```
Learning: Enabled
```

```
Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
```

```
Description: none
```

```
service-tpid: dot1.ad
```

```
Operating mode: Tagged
```

```
Svlan Id: 0
```

```
Svlan Tpid: 88a8
```

```
Configured interfaces:
```

```
Interface: xe1
```

```
Service-template : template1
```

```
Match criteria : 2024/2023
```

```
Mesh Peers:
```

```
23.23.23.23 (Up)
```

```
Virtual Private LAN Service Instance: v2, ID: 26
```

```
SIG-Protocol: LDP
```

```
Attachment-Circuit :UP
```

```
Learning: Enabled
```

```
Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
```

```
Description: none
```

```
service-tpid: dot1.ad
```

```
Operating mode: Tagged
```

```
Svlan Id: 0
```

```
Svlan Tpid: 88a8
```

```
Configured interfaces:
```

```
Interface: xe1
```

```
Service-template : template2
```

```
Match criteria : 2030/2024
```

```
Action type : Translate
```

```
Action value : 2026
```

Outgoing tpid : dot1.q

Mesh Peers:

23.23.23.23 (Up)

Virtual Private LAN Service Instance: v3, ID: 27

SIG-Protocol: LDP

Attachment-Circuit :UP

Learning: Enabled

Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Tagged

Svlan Id: 0

Svlan Tpid: 8100

Configured interfaces:

Interface: xel

Service-template : template3

Match criteria : Accept all

Action type : Push

Action value : 300

Mesh Peers:

23.23.23.23 (Up)

Virtual Private LAN Service Instance: v4, ID: 28

SIG-Protocol: LDP

Attachment-Circuit :UP

Learning: Enabled

Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500

Description: none

service-tpid: dot1.q

Operating mode: Tagged

Svlan Id: 0

Svlan Tpid: 8100

Configured interfaces:

Interface: xel

Service-template : template4

Match criteria : 700

1200/3200

Untagged

Action type : Push

Action value : 300

Mesh Peers:

23.23.23.23 (Up)

CHAPTER 8 BGP-VPLS Service Mapping Configuration

Overview

This chapter includes step-by-step configurations for BGP VPLS. It also contains an overview of the concepts of BGP VPLS. Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint-to-multipoint communication over IP- MPLS networks. It allows geographically-dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires

Topology

The diagram depicts the topology for the configuration examples that follow.

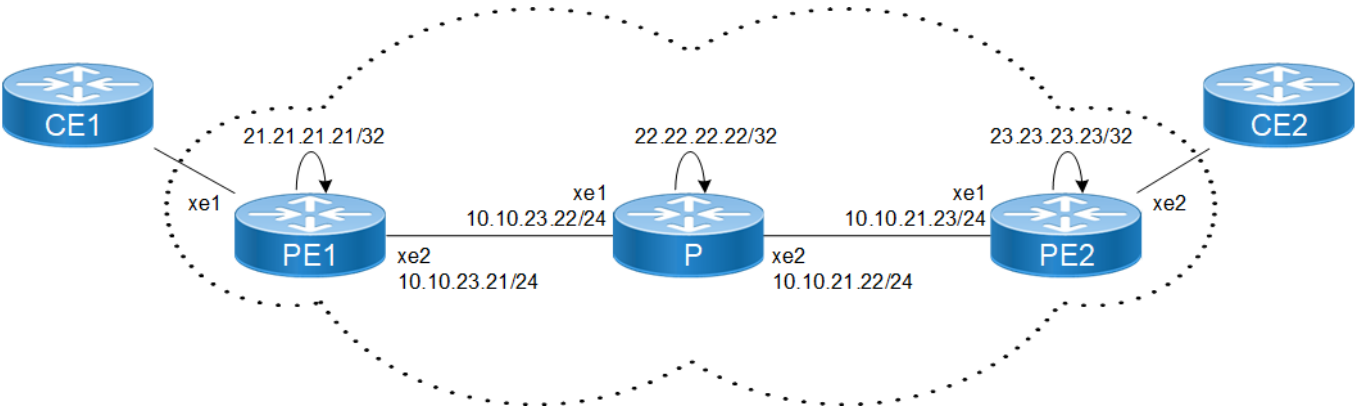


Figure 8-23: BGP-VPLS service mapping

Configuration

PE1: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 21.21.21.21/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

PE1: Interface Configuration

(config)#interface xe2	Enter the Interface mode for xe2.
(config-if)# ip address 10.10.23.21/24	Configure IP address on the interface.
(config-if)#enable-rsvp	Enable RSVP on the physical interface

(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

PE1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 21.21.21.21	Router-id configurations
(config-router)#network 21.21.21.21/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 10.10.23.0/24 area 0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.

PE1: Global RSVP

(config)#router rsvp	Enter the Router OSPF mode.
(config-router)#exit	Exit Router RSVP mode and return to Configure mode.

PE1: RSVP-Trunk Configuration

(config)#rsvp-trunk 1	Enter the Trunk configuration mode
(config-trunk)#to 23.23.23.23	Configure the destination of the Trunk
(config-trunk)#exit	Exit.Trunk configuration mode

PE1: BGP Configuration

(config)# router bgp 100	Enter the BGP configuration mode.
(config-router)#neighbor 23.23.23.23 remote-as 100	Configure neighbor
(config-router)#neighbor 23.23.23.23 update-source 21.21.21.21	Update loopback address as source
(config-router)#address-family l2vpn vpls	Enter address family mode.
(config-router-af)#neighbor 23.23.23.23 activate	Activate the neighbor.
(config-router-af)#exit	Exit address family mode.
(config-router)#exit	Exit Router BGP mode

PE1: BGP VPLS Configuration

(config)#mpls vpls v1 25	Enter VPLS config mode
(config)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling bgp	Define Signaling as BGP
(config-vpls-sig)#ve-id 1	Configure VE-ID
(config-vpls-sig)#exit	Exit Signaling BGP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v2 26	Enter VPLS config mode

(config)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling bgp	Define Signaling as BGP
(config-vpls-sig)#ve-id 1	Configure VE-ID
(config-vpls-sig)#exit	Exit Signaling BGP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v3 27	Enter VPLS config mode
(config-vpls)#signaling bgp	Define Signaling as BGP
(config-vpls-sig)#ve-id 1	Configure VE-ID
(config-vpls-sig)#exit	Exit Signaling BGP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v4 28	Enter VPLS config mode
(config-vpls)#signaling bgp	Define Signaling as BGP
(config-vpls-sig)#ve-id 1	Configure VE-ID
(config-vpls-sig)#exit	Exit Signaling BGP mode
(config-vpls)#exit	Exit VPLS mode
(config)#commit	Commit candidate configuration to running configuration

P1: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 22.22.22.22/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

P1: Interface Configuration

(config)#interface xe1	Enter the Interface mode for xe1
(config-if)#ip address 10.10.23.22/24	Configure IP address on the interface.
(config-if)#enable-rsvp	Enable RSVP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter the Interface mode for xe2
(config-if)#ip address 10.10.21.22/24	Configure IP address on the interface.
(config-if)#enable-rsvp	Enable RSVP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

P1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 22.22.22.22/32 area 0	Advertise loopback address in OSPF.

(config-router)#network 10.10.23.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 10.10.21.0/24 area 0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.

P1: Global RSVP

(config)#router rsvp	Enter the Router OSPF mode.
(config-router)#exit	Exit Router RSVP mode and return to Configure mode.
(config)#commit	Commit candidate configuration to running configuration

PE2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 23.23.23.23/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

PE2: Interface Configuration

(config)#interface xe1	Enter the Interface mode for xe1
(config-if)#ip address 10.10.21.23/24	Configure IP address on the interface.
(config-if)#enable-rsvp	Enable RSVP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

PE2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 23.23.23.23/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 10.10.21.0/24 area 0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.

PE2: Global RSVP

(config)#router rsvp	Enter the Router OSPF mode.
(config-router)#exit	Exit Router RSVP mode and return to Configure mode.

PE2: RSVP-Trunk Configuration

(config)#rsvp-trunk 1	Enter the Trunk configuration mode
(config-trunk)#to 21.21.21.21	Configure the destination of the Trunk
(config-trunk)#exit	Exit.Trunk configuration mode

PE2: BGP Configuration

(config)# router bgp 100	Enter the BGP configuration mode.
(config-router)#neighbor 21.21.21.21 remote-as 100	Configure neighbor
(config-router)#neighbor 21.21.21.21 update-source 23.23.23.23	Update loopback address as source
(config-router)#address-family l2vpn vpls	Enter address family mode.
(config-router-af)#neighbor 21.21.21.21 activate	Activate the neighbor.
(config-router-af)#exit	Exit address family mode.
(config-router)#exit	Exit Router BGP mode

PE2: BGP VPLS Configuration

(config)#mpls vpls v1 25	Enter VPLS config mode
(config)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling bgp	Define Signaling as BGP
(config-vpls-sig)#ve-id 2	Configure VE-ID
(config-vpls-sig)#exit	Exit Signaling BGP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v2 26	Enter VPLS config mode
(config)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling bgp	Define Signaling as BGP
(config-vpls-sig)#ve-id 2	Configure VE-ID
(config-vpls-sig)#exit	Exit Signaling BGP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v3 27	Enter VPLS config mode
(config-vpls)#signaling bgp	Define Signaling as BGP
(config-vpls-sig)#ve-id 2	Configure VE-ID
(config-vpls-sig)#exit	Exit Signaling BGP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v4 28	Enter VPLS config mode
(config-vpls)#signaling bgp	Define Signaling as BGP
(config-vpls-sig)#ve-id 2	Configure VE-ID
(config-vpls-sig)#exit	Exit Signaling BGP mode
(config-vpls)#exit	Exit VPLS mode
(config)#commit	Commit candidate configuration to running configuration

BGP VPLS Service Mapping Configuration

PE1: POP

(config)#configure terminal	Configure mode
(config)#service-template template1	Template configuration
(config-svc)# match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)# rewrite ingress pop outgoing-tpid dot1.q	Action to be performed for the match.
(config-svc)#exit	Exit template configuration mode

PE1: XLATE

(config)#service-template template2	Template configuration
(config-svc)# match double-tag outer-vlan 2030 inner-vlan 2024	Match criteria under template configuration
(config-svc)# rewrite ingress translate 2026 outgoing-tpid dot1.q	Action to be performed for the match
(config-svc)#exit	Exit template configuration mode

PE1: PUSH

(config)#service-template template3	Template configuration
(config-svc)# match outer-vlan 500	Match criteria under template configuration
(config-svc)# rewrite ingress push 300	Action to be performed for the default match.
(config-svc)#exit	Exit template configuration mode

PE1: PUSH-service-template with multiple match

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config-svc)#exit	Exit configure SVC mode

PE1: Access port Configuration

(config)#interface xe1	Enter the Interface mode for xe1.
(config-if) switchport	Configure interface as L2 interface

(config-if)#mpls-vpls v1 service-template template1	Bind the VPLS to the Access Interface.
(config-if-vpls)no ac-admin-status	Making Ac-admin-status Up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v2 service-template template2	Bind the VPLS to the Access Interface.
(config-if-vpls)no ac-admin-status	Making Ac-admin-status Up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v3 service-template template3	Bind the VPLS to the Access Interface.
(config-if-vpls)#no ac-admin-statusv	Making Ac-admin-status Up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v4 service-template template4	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#no ac-admin-status	Making Ac-admin-status Up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#commit	Commit candidate configuration to running configuration

PE2: POP

(config)#configure terminal	Configure mode
(config)#service-template template1	Template configuration
(config-svc)# match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)# rewrite ingress pop outgoing-tpid dot1.ad	Action to be performed for the match.
(config-svc)#exit	Exit template configuration mode

PE2: XLATE

(config)#service-template template2	Template configuration
(config-svc)# match double-tag outer-vlan 2030 inner-vlan 2024	Match criteria under template configuration
(config-svc)# rewrite ingress translate 2026 outgoing-tpid dot1.q	Action to be performed for the match
(config-svc)#exit	Exit template configuration mode

PE2: PUSH

(config)#service-template template3	Template configuration
(config-svc)# match outer-vlan 500	Match criteria under template configuration
(config-svc)# rewrite ingress push 300	Action to be performed for the default match.
(config-svc)#exit	Exit template configuration mode

PE2: PUSH-service-template with multiple match

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config-svc)#exit	Exit configure SVC mode

PE2: Access port Configuration

(config)#interface eth2	Enter the Interface mode for ethernet1.
(config-if)switchport	Configure interface as L2 interface
(config-if)#mpls-vpls v1 service-template template1	Bind the VPLS to the Access Interface.
(config-if-vpls)#no ac-admin-status	Making admin status up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v2 service-template template2	Bind the VPLS to the Access Interface.
(config-if-vpls)#no ac-admin-status	Making admin status up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v3 service-template template3	Bind the VPLS to the Access Interface.
(config-if-vpls)#no ac-admin-status	Making admin status up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v4 service-template template4	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#no ac-admin-status	Making Ac-admin-status Up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#commit	Commit candidate configuration to running configuration

Validation

PE1

```
PE1#show bgp l2vpn vpls
VPLS-ID      VE-ID      Discovered-Peers  Route-Target
25           1          1                 100:25
26           1          1                 100:26
27           1          1                 100:27
28           1          1                 100:28
```

```
PE1#show bgp l2vpn vpls detail
```

```
VPLS ID: 25
VE-ID: 1
Discovered Peers: 1
Route-Target: 100:25
Local RD: 100:25
Mesh Peers:
  Address:23.23.23.23, RD:100:25, VE-ID:2
  VC Details: VC-ID:12
  Remote (LB:25216,VBO:1,VBS:64)  Local (LB:26240,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:26241, Out Label:25216
  PW Status:Established
  VC Installed:Yes
```

```
VPLS ID: 26
VE-ID: 1
Discovered Peers: 1
Route-Target: 100:26
Local RD: 100:26
Mesh Peers:
  Address:23.23.23.23, RD:100:26, VE-ID:2
  VC Details: VC-ID:12
  Remote (LB:25280,VBO:1,VBS:64)  Local (LB:26304,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:26305, Out Label:25280
  PW Status:Established
  VC Installed:Yes
```

```
VPLS ID: 27
VE-ID: 1
Discovered Peers: 1
Route-Target: 100:27
Local RD: 100:27
Mesh Peers:
  Address:23.23.23.23, RD:100:27, VE-ID:2
  VC Details: VC-ID:12
  Remote (LB:25344,VBO:1,VBS:64)  Local (LB:26368,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:26369, Out Label:25344
  PW Status:Established
  VC Installed:Yes
```

```
VPLS ID: 28
VE-ID: 1
Discovered Peers: 1
Route-Target: 100:28
Local RD: 100:28
Mesh Peers:
  Address:23.23.23.23, RD:100:28, VE-ID:2
  VC Details: VC-ID:12
  Remote (LB:25408,VBO:1,VBS:64)  Local (LB:26432,VBO:1,VBS:64)
```

```

LB sent on known VEID:Yes
In Label:26433, Out Label:25408
PW Status:Established
VC Installed:Yes

```

```

PE1#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label
Lkps/St	PW-INDEX SIG-Protocol	Status			
25	23.23.23.23	25601	26241	xe2	25216
2/Up	1 BGP	Active			
26	23.23.23.23	25601	26305	xe2	25280
2/Up	3 BGP	Active			
27	23.23.23.23	25601	26369	xe2	25344
2/Up	2 BGP	Active			
28	23.23.23.23	25601	26433	xe2	25408
2/Up	4 BGP	Active			

PE2:

```

PE1#show bgp l2vpn vpls
VPLS-ID    VE-ID    Discovered-Peers    Route-Target
25          2        1                    100:25
26          2        1                    100:26
27          2        1                    100:27
28          2        1                    100:28

```

```

PE1#show bgp l2vpn vpls detail

```

```

VPLS ID: 25
VE-ID: 2
Discovered Peers: 1
Route-Target: 100:25
Local RD: 100:25
Mesh Peers:
  Address:21.21.21.21, RD:100:25, VE-ID:1
  VC Details: VC-ID:21
  Remote (LB:26240,VBO:1,VBS:64)  Local (LB:25216,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25216, Out Label:26241
  PW Status:Established
  VC Installed:Yes
All Local LB:
  LB:25216,VBO:1,VBS:64

```

```

VPLS ID: 26
VE-ID: 2
Discovered Peers: 1
Route-Target: 100:26
Local RD: 100:26

```

```

Mesh Peers:
  Address:21.21.21.21, RD:100:26, VE-ID:1
  VC Details: VC-ID:21
  Remote (LB:26304,VBO:1,VBS:64)  Local (LB:25280,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25280, Out Label:26305
  PW Status:Established
  VC Installed:Yes
All Local LB:
  LB:25280,VBO:1,VBS:64

```

```

VPLS ID: 27
VE-ID: 2
Discovered Peers: 1
Route-Target: 100:27
Local RD: 100:27
Mesh Peers:
  Address:21.21.21.21, RD:100:27, VE-ID:1
  VC Details: VC-ID:21
  Remote (LB:26368,VBO:1,VBS:64)  Local (LB:25344,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25344, Out Label:26369
  PW Status:Established
  VC Installed:Yes
All Local LB:
  LB:25344,VBO:1,VBS:64

```

```

VPLS ID: 28
VE-ID: 2
Discovered Peers: 1
Route-Target: 100:28
Local RD: 100:28
Mesh Peers:
  Address:21.21.21.21, RD:100:28, VE-ID:1
  VC Details: VC-ID:21
  Remote (LB:26432,VBO:1,VBS:64)  Local (LB:25408,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25408, Out Label:26433
  PW Status:Established
  VC Installed:Yes
All Local LB:
  LB:25408,VBO:1,VBS:64

```

```

PE1#show mpls vpls mesh
(m) - Service mapped over multipath transport

```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label
Lkps/St	PW-INDEX SIG-Protocol	Status			
25	21.21.21.21	25600	25216	xe1	26241
2/Up	1 BGP	Active			
26	21.21.21.21	25600	25280	xe1	26305
2/Up	3 BGP	Active			
27	21.21.21.21	25600	25344	xe1	26369
2/Up	2 BGP	Active			

28	21.21.21.21	25600	25408	xe1	26433
2/Up	4	BGP	Active		

PE1#show mpls vpls detail

Virtual Private LAN Service Instance: v1, ID: 25

SIG-Protocol: BGP

Route-Distinguisher :100:25

Route-Target :100:25

VE-ID :2

Attachment-Circuit :UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, Configured MTU: 1500

Description: none

service-tpid: dot1.ad

Operating mode: Raw

Configured interfaces:

Interface: xe9

Service-template : template1

Match criteria : 2024/2023

Action type : Pop

Outgoing tpid : dot1.q

Mesh Peers:

21.21.21.21 (Up)

Virtual Private LAN Service Instance: v2, ID: 26

SIG-Protocol: BGP

Route-Distinguisher :100:26

Route-Target :100:26

VE-ID :2

Attachment-Circuit :UP

Learning: Enabled

Control-Word: Disabled

Flow Label Status: Disabled, Direction: None, Static: No

Group ID: 0, Configured MTU: 1500

Description: none

service-tpid: dot1.ad

Operating mode: Raw

Configured interfaces:

Interface: xe9

Service-template : template2

Match criteria : 2030/2024

Action type : Translate

Action value : 2026

Outgoing tpid : dot1.q

Mesh Peers:

21.21.21.21 (Up)

Virtual Private LAN Service Instance: v3, ID: 27

SIG-Protocol: BGP

Route-Distinguisher :100:27

Route-Target :100:27


```
VE-ID :2
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
  Interface: xe9
Service-template : template3
Match criteria : 500
Action type : Push
Action value : 300
```

```
Mesh Peers:
  21.21.21.21 (Up)
```

```
Virtual Private LAN Service Instance: v4, ID: 28
SIG-Protocol: BGP
  Route-Distinguisher :100:28
  Route-Target :100:28
  VE-ID :2
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
  Interface: xe9
Service-template : template4
Match criteria : 700,
Untagged ,
1200/3200
  Action type : Push
  Action value : 300
```

```
Mesh Peers:
  21.21.21.21 (Up)
```

CHAPTER 9 Hierarchical VPLS

Overview

A Virtual Private LAN Service (VPLS) enables multipoint to multipoint communication, creating LAN-like connectivity between customers' sites. However, the typical full mesh topology required for LAN emulation can be impractical in large networks. To address this, Hierarchical VPLS (H-VPLS) introduces a hierarchical approach using a spoke-PW (pseudowire) type. Unlike the standard mesh-PW, the spoke-PW facilitates traffic between hierarchical levels, offering a more scalable solution for VPLS networks.

H-VPLS Redundancy Characteristics

In a Virtual Private LAN Service (VPLS) network, when a node connects through a spoke-PW, a single point of failure arises. In the event of a connection failure to the VPLS mesh or a failure within the PE-rs node, the spoke device experiences a complete loss of connectivity. To address this, PW redundancy is implemented, configuring a secondary path that activates if the primary path fails. The MTU-s is configured with a primary spoke-PW connected to PE1-rs and a secondary spoke-PW connected to PE2-rs. During normal operation, the primary spoke-PW is active, but in case of failure, the MTU-s can switch to the standby spoke-PW for continued connectivity, aiming for sub-second convergence times with potential MAC flush-related traffic loss.

Benefits

Hierarchical VPLS (H-VPLS) is introduced to address scalability challenges associated with the traditional VPLS (Virtual Private LAN Service) architecture. It introduces a hierarchical approach that enhances scalability, reduces configuration complexity, optimizes traffic flow, and improves overall network efficiency and fault tolerance.

Limitations

- Automatic revertive cases from secondary to primary will not be supported.
- MAC Address Withdrawal feature will not be supported in release 6.5.2.
- Convergence on redundancy may require bidirectional traffic or MAC aging.

Prerequisites

- The `block-mesh-spoke-on-all-ac-down` and `ignore-ac-spoke-state` commands are optional and mutually exclusive, meaning only one can be applied at a time, or neither. By default, neither command is applied. If one of commands is applied, applying the other will make it the active one. To remove a command, use the `no` prefix.

```
signaling ldp
  (block-mesh-spoke-on-all-ac-down | ignore-ac-spoke-state)
  (no block-mesh-spoke-on-all-ac-down | no ignore-ac-spoke-state)
```

- **Define Interfaces and Loopback Addresses:**

Configure Layer 2 interfaces, like port channel interfaces (e.g., po1), and assign specific IP addresses for proper identification and routing. Additionally, assign loopback IP addresses to establish essential points of connectivity. These configurations establish the efficient network routing and communication.

```
!
interface lo
```

```
ip address 127.0.0.1/8
ip address 2.2.2.2/32 secondary
ipv6 address ::1/128
```

```
interface xe14
 ip address 30.1.1.2/24
```

- **Configure IGP for Dynamic Routing:** Enable ISIS to facilitate dynamic routing on all nodes within the network. Define ISIS router instances to match loopback IP addresses and add network segments to ISIS areas for proper route distribution. Set up neighbor relationships using loopback IP addresses, ensuring efficient route advertisement and convergence for optimal network performance.

ISIS Configuration:

```
router isis 1
 is-type level-2-only
 metric-style wide
 microloop-avoidance level-2
 mpls traffic-eng router-id 2.2.2.2
 mpls traffic-eng level-2
 capability cspf
 dynamic-hostname
 bfd all-interfaces
 net 49.0000.0000.0002.00
 passive-interface lo
!
interface xe14
 mpls ldp-igp sync isis level-2
 isis network point-to-point
 ip router isis 1
```

OSPF Configuration:

```
router ospf 1
 ospf router-id 2.2.2.2
 network 2.2.2.2/32 area 0.0.0.0
 network 30.1.1.0/24 area 0.0.0.0!
!
interface xe14
 ip ospf network point-to-point
```

Configuration for H-VPLS with Redundancy

Configure various nodes within the topology to set up a H-VPLS session.

Topology

This sample topology provides basic connectivity and routing between the devices.

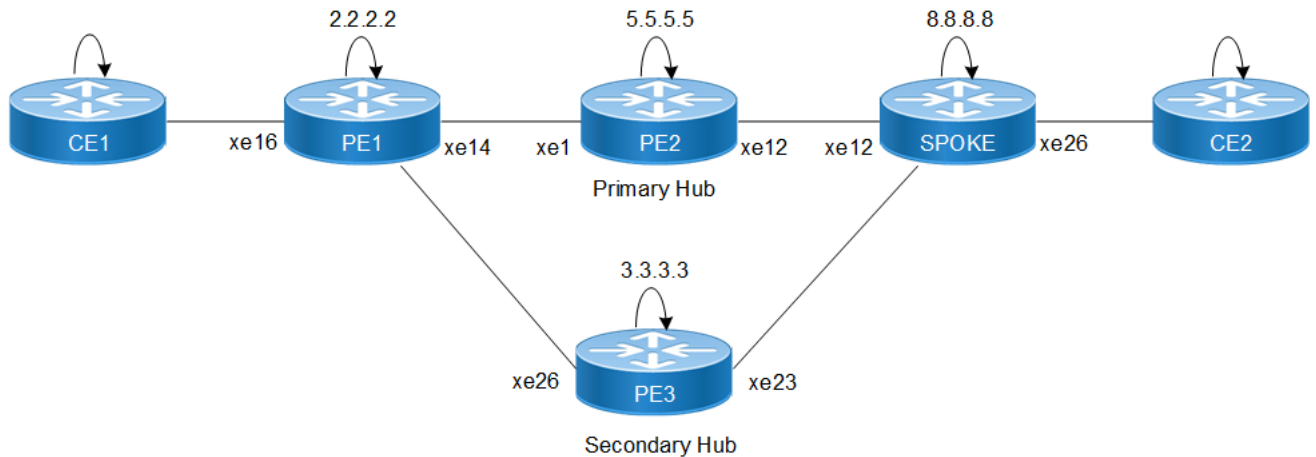


Figure 9-24: H-VPLS Configuration with Redundancy

Configure H-VPLS on PE1 Router

Follow the steps to configure the H-VPLS on PE1 router:

1. Configure router LDP.

```
PE1(config)#router ldp
PE1(config-router)# router-id 2.2.2.2
PE1(config-router)# transport-address ipv4 2.2.2.2
```

2. Configure targeted-peer under router LDP.

```
PE1(config-router)# targeted-peer ipv4 5.5.5.5
PE1(config-router-targeted-peer)# exit-targeted-peer-mode
PE1(config-router)# targeted-peer ipv4 3.3.3.3
PE1(config-router-targeted-peer)# exit-targeted-peer-mode
```

3. Enable LDP and label-switching for core interface.

```
PE1(config)#interface xe14
PE1(config-if)# enable-ldp ipv4
PE1(config-if)#label-switching

PE1(config)#interface xe26
PE1(config-if)# enable-ldp ipv4
PE1(config-if)#label-switching
```

4. Configure VPLS instance.

```
PE1(config)#mpls vpls vpls2000 2000
PE1(config-vpls)# signaling ldp
PE1(config-vpls-sig)# vpls-peer 3.3.3.3
PE1(config-vpls-sig)# vpls-peer 5.5.5.5
PE1(config-vpls-sig)# exit-signaling
PE1(config-vpls)# exit-vpls
PE1(config)#
```

5. Configure sub-interface and attach vpls-instance to sub-interface.

```
PE1(config)#
PE1(config)#interface xe16.2000 switchport
PE1(config-if)# encapsulation dot1q 2000
PE1(config-if)# access-if-vpls
```

```
PE1(config-acc-if-vpls)# mpls-vpls vpls2000
PE1(config-acc-if-vpls)#
```

Configure H-VPLS on PE2 (Primary Hub)

Follow the steps to configure the H-VPLS on PE2 (Primary Hub):

1. Configure router LDP.

```
PE2(config)#router ldp
PE2(config-router)# router-id 5.5.5.5
PE2(config-router)# transport-address ipv4 5.5.5.5
```

2. Configure targeted-peer under router LDP.

```
PE2(config)#router ldp
PE2(config-router)# targeted-peer ipv4 2.2.2.2
PE2(config-router-targeted-peer)# exit-targeted-peer-mode
PE2(config-router)# targeted-peer ipv4 3.3.3.3
PE2(config-router-targeted-peer)# exit-targeted-peer-mode
PE2(config-router)#
```

3. Enable LDP and label-switching for core interface.

```
PE2(config)#interface xe1
PE2(config-if)# enable-ldp ipv4
PE2(config-if)#label-switching
```

```
PE2(config)#interface xe12
PE2(config-if)# enable-ldp ipv4
PE2(config-if)#label-switching
```

4. Configure VPLS instance.

```
PE2(config)#mpls vpls vpls2000 2000
PE2(config-vpls)# signaling ldp
PE2(config-vpls-sig)# vpls-peer 2.2.2.2
PE2(config-vpls-sig)# vpls-peer 3.3.3.3
PE2(config-vpls-sig)# exit-signaling
PE2(config-vpls)# exit-vpls
PE2(config)#
```

5. Configure L2-ckt.

```
PE2(config)#mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
PE2(config-pseudowire)#
```

6. Attach L2-ckt under vpls instance.

```
PE2(config)#mpls vpls vpls2000 2000
PE2(config-vpls)#vpls-vc vc2000
PE2(config-vpls-spoke)#
```

Configure H-VPLS on PE3 (Secondary Hub)

Follow the steps to configure the H-VPLS on PE3 (Secondary Hub):

1. Configure router LDP.

```
PE3(config)#router ldp
PE3(config-router)# router-id 3.3.3.3
PE3(config-router)# transport-address ipv4 3.3.3.3
```

2. Configure targeted-peer under router LDP.

```

PE3(config)#router ldp
PE3(config-router)# targeted-peer ipv4 2.2.2.2
PE3(config-router-targeted-peer)# exit-targeted-peer-mode
PE3(config-router)# targeted-peer ipv4 5.5.5.5
PE3(config-router-targeted-peer)# exit-targeted-peer-mode
PE3(config-router)#

```

3. Enable LDP and label-switching for core interface.

```

PE3(config)#interface xe23
PE3(config-if)# enable-ldp ipv4
PE3(config-if)#label-switching

```

```

PE3(config)#interface xe26
PE3(config-if)# enable-ldp ipv4
PE3(config-if)#label-switching

```

4. Configure VPLS instance.

```

PE3(config)#mpls vpls vpls2000 2000
PE3(config-vpls)# signaling ldp
PE3(config-vpls-sig)# vpls-peer 2.2.2.2
PE3(config-vpls-sig)# vpls-peer 5.5.5.5
PE3(config-vpls-sig)# exit-signaling
PE3(config-vpls)# exit-vpls
PE3(config)#

```

5. Configure L2-ckt.

```

PE3(config)#mpls l2-circuit vc2001 2223 8.8.8.8 mode raw
PE3(config-pseudowire)#

```

6. Attach L2-ckt under vpls instance.

```

PE3 (config)#mpls vpls vpls2000 2000
PE3(config-vpls)#vpls-vc vc2001
PE3(config-vpls-spoke)#

```

Configure H-VPLS on Spoke Router

Follow the steps to configure the H-VPLS on Spoke router:

1. Configure router LDP.

```

Spoke(config)#router ldp
Spoke(config-router)# router-id 8.8.8.8
Spoke(config-router)# transport-address ipv4 8.8.8.8

```

2. Configure targeted-peer under router LDP.

```

Spoke(config-router)# targeted-peer ipv4 5.5.5.5
Spoke(config-router-targeted-peer)# exit-targeted-peer-mode
Spoke(config-router)# targeted-peer ipv4 3.3.3.3
Spoke(config-router-targeted-peer)# exit-targeted-peer-mode

```

3. Enable LDP and label-switching for core interface.

```

Spoke(config)#interface xe12
Spoke(config-if)# enable-ldp ipv4
Spoke(config-if)#label-switching

```

```

Spoke(config)#interface xe25
Spoke(config-if)# enable-ldp ipv4
Spoke(config-if)#label-switching

```

4. Configure VPLS instance.

```
Spoke (config)#mpls vpls vpls2000 2000
Spoke (config-vpls)#
```

5. 5.Configure L2-ckt.

```
Spoke(config)#mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
Spoke(config-pseudowire)#!
Spoke(config-pseudowire)#mpls l2-circuit vc2001 2223 3.3.3.3 mode raw
Spoke(config-pseudowire)#
```

6. 6.Configure Primary and secondary spoke under vpls instance.

```
Spoke(config)#mpls vpls vpls2000 2000
Spoke(config-vpls)#vpls-vc vc2000
Spoke(config-vpls-spoke)# secondary vc2001
Spoke(config-vpls-spoke)# exit-spoke
Spoke(config-vpls)# exit-vpls
Spoke(config)#
```

7. Configure sub-interface and attach vpls-instance to sub-interface.

```
Spoke(config)#
Spoke(config)#interface xe26.2000 switchport
Spoke(config-if)# encapsulation dot1q 2000
Spoke(config-if)# access-if-vpls
Spoke(config-acc-if-vpls)# mpls-vpls vpls2000
Spoke(config-acc-if-vpls)#
```

Running Configuration on PE1 Router

```
router ldp
router-id 2.2.2.2
targeted-peer ipv4 3.3.3.3
exit-targeted-peer-mode
targeted-peer ipv4 5.5.5.5
transport-address ipv4 2.2.2.2
!
interface xe14
enable-ldp ipv4
!
interface xe26
enable-ldp ipv4
!
mpls vpls vpls2000 2000
signaling ldp
vpls-peer 3.3.3.3
vpls-peer 5.5.5.5
exit-signaling
exit-vpls
!
interface xe16.2000 switchport
access-if-vpls
mpls-vpls vpls2000
```

Running Configuration on PE2 Router

```
router ldp
targeted-peer ipv4 2.2.2.2
```

```
    exit-targeted-peer-mode
    targeted-peer ipv4 3.3.3.3
    exit-targeted-peer-mode
transport-address ipv4 5.5.5.5
!
mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
!
mpls vpls vpls2000 2000
  vpls-vc vc2000
  exit-spoke
  signaling ldp
  vpls-peer 2.2.2.2
  vpls-peer 3.3.3.3
  exit-signaling
exit-vpls
```

Running Configuration on PE3 Router

```
router ldp
  targeted-peer ipv4 2.2.2.2
  exit-targeted-peer-mode
  targeted-peer ipv4 5.5.5.5
  exit-targeted-peer-mode
transport-address ipv4 3.3.3.3
!
mpls l2-circuit vc2001 2223 8.8.8.8 mode raw
!
mpls vpls vpls2000 2000
  vpls-vc vc2001
  exit-spoke
  signaling ldp
  vpls-peer 2.2.2.2
  vpls-peer 5.5.5.5
  exit-signaling
exit-vpls
```

Running Configuration on Spoke Router

```
router ldp
  router-id 8.8.8.8
  targeted-peer ipv4 3.3.3.3
  exit-targeted-peer-mode
  targeted-peer ipv4 5.5.5.5
  exit-targeted-peer-mode
transport-address ipv4 8.8.8.8
!
mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
!
mpls l2-circuit vc2001 2223 3.3.3.3 mode raw
!
mpls vpls vpls2000 2000
  vpls-vc vc2000
    secondary vc2001
  exit-spoke
exit-vpls
!
```



```
interface xe26.2000 switchport
access-if-vpls
mpls-vpls vpls2000
```

Validation

Validate the show output after configuration as shown below.
Verify vpls mesh are up between PE1 and Hub Nodes

```
PE1#sho mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label
Lkps/St	PW-INDEX	SIG-Protocol	Status	UpTime	
2000	3.3.3.3	29447	28164	xe26	27532
2/Up	3	LDP	Active	2d12h08m	
2000	5.5.5.5	31364	28162	xe14	26883
2/Up	4	LDP	Active	2d12h04m	

```
PE2#sho mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label
Lkps/St	PW-INDEX	SIG-Protocol	Status	UpTime	
2000	2.2.2.2	29446	26883	xe1	28162
Up	3	LDP	Active	2d12h05m	2/
2000	3.3.3.3	31367	26884	xe1	27528
2/Up	4	LDP	Active	2d12h15m	

```
PE3#sho mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label
Lkps/St	PW-INDEX	SIG-Protocol	Status	UpTime	
2000	2.2.2.2	29440	27532	xe26	28164
2/Up	3	LDP	Active	2d12h10m	
2000	5.5.5.5	31363	27528	xe26	26884
2/Up	4	LDP	Active	2d12h16m	

Verify vpls spoke between Hub and Spoke

```
PE2#sho mpls vpls spoke
VPLS-ID    Virtual Circuit  Tunnel-Label  In-Label    Network-Intf  Out-Label
Lkps/St    Secondary
2000      vc2000           29443         26882       xe1            26886
2/Up      ---
```

```
PE3#show mpls vpls spoke
VPLS-ID    Virtual Circuit  Tunnel-Label  In-Label    Network-Intf  Out-Label
Lkps/St    Secondary
2000      vc2001           N/A           27527       N/A            26883
0/Dn      ---
```

```
Spoke#show mpls vpls spoke
```

VPLS-ID	Virtual Circuit	Tunnel-Label	In-Label	Network-Intf	Out-Label
Lkps/St	Secondary				
2000	vc2000	29440	26886	xe12	26882
2/Up	vc2001				
2000	vc2001	N/A	26883	N/A	27527
0/Dn	---				

Verify H-vpls session on Hub and spoke:

```
PE2#show mpls vpls vpls2000
Virtual Private LAN Service Instance: vpls2000, ID: 2000
  SIG-Protocol: LDP
  Attachment-Circuit: UP
  Learning: Enabled
  Control-Word: Disabled
  Flow Label Status: Disabled, Direction: None, Static: No
  Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
  Description: none
  service-tpid: dot1.q
  Operating mode: Raw
  Ignoring AC interface and spoke-VC state
```

```
Configured interfaces:
  None
```

Mesh Peers:

```
  2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d12h13m)
  3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d12h22m)
```

Spoke Peers:

```
  vc2000 (Up) (UpTime 01:31:27)
```

```
PE3#show mpls vpls vpls2000
Virtual Private LAN Service Instance: vpls2000, ID: 2000
  SIG-Protocol: LDP
  Attachment-Circuit: UP
  Learning: Enabled
  Control-Word: Disabled
  Flow Label Status: Disabled, Direction: None, Static: No
  Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
  Description: none
  service-tpid: dot1.q
  Operating mode: Raw
  Ignoring AC interface and spoke-VC state
```

```
Configured interfaces:
  None
```

Mesh Peers:

```
  2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d12h16m)
  5.5.5.5 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d12h22m)
```

Spoke Peers:

```
  vc2001 (Dn) (Reason: VC on standby)
```

```
Spoke#show mpls vpls vpls2000
Virtual Private LAN Service Instance: vpls2000, ID: 2000
```

```

SIG-Protocol: N/A
Attachment-Circuit: UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw

```

```

Configured interfaces:
Interface: xe26.2000
Status: Up
Subinterface Match Criteria(s) :
dot1q 2000

```

```

Spoke Peers:
vc2000 (Up) (UpTime 01:31:33)
Secondary: vc2001 (Dn) (Reason: VC on standby)

```

Configuration for H-VPLS without Redundancy

Configure various nodes within the topology to set up a H-VPLS session.

Topology

This sample topology provides basic connectivity and routing between the devices.

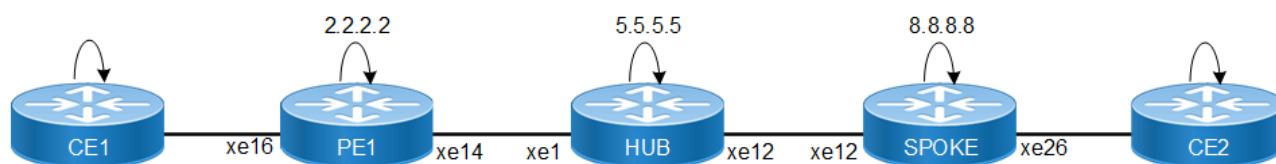


Figure 9-25: H-VPLS Configuration without Redundancy

Configure H-VPLS on PE1 Router

Follow the steps to configure the H-VPLS on PE1 router:

1. Configure router LDP.


```

PE1(config)#router ldp
PE1(config-router)# router-id 2.2.2.2
PE1(config-router)# transport-address ipv4 2.2.2.2

```
2. Configure targeted-peer under router LDP.


```

PE1(config-router)# targeted-peer ipv4 5.5.5.5
PE1(config-router-targeted-peer)# exit-targeted-peer-mode

```
3. Enable LDP and label-switching for core interface.


```

PE1(config)#interface xe14
PE1(config-if)# enable-ldp ipv4
PE1(config-if)#label-switching

```

4. Configure VPLS instance.

```

PE1(config)#mpls vpls vpls2000 2000
PE1(config-vpls)# signaling ldp
PE1(config-vpls-sig)# vpls-peer 5.5.5.5
PE1(config-vpls-sig)# exit-signaling
PE1(config-vpls)# exit-vpls
PE1(config)#

```

5. Configure sub-interface and attach vpls-instance to sub-interface

```

PE1(config)#
PE1(config)#interface xe16.2000 switchport
PE1(config-if)# encapsulation dot1q 2000
PE1(config-if)# access-if-vpls
PE1(config-acc-if-vpls)# mpls-vpls vpls2000
PE1(config-acc-if-vpls)#

```

Configure H-VPLS on Hub Router

Follow the steps to configure the H-VPLS on Hub router:

1. Configure router LDP.

```

Hub(config)#router ldp
Hub(config-router)# router-id 5.5.5.5
Hub(config-router)# transport-address ipv4 5.5.5.5

```

2. Configure targeted-peer under router LDP.

```

Hub(config-router)# targeted-peer ipv4 2.2.2.2
Hub(config-router-targeted-peer)# exit-targeted-peer-mode
R5-P5(config-router)# targeted-peer ipv4 8.8.8.8
R5-P5(config-router-targeted-peer)#

```

3. Enable LDP and label-switching for core interface.

```

Hub(config)#interface xe1
Hub(config-if)# enable-ldp ipv4
Hub(config-if)#label-switching

Hub(config)#interface xe12
Hub(config-if)# enable-ldp ipv4
Hub(config-if)#label-switching

```

4. Configure VPLS instance.

```

Hub(config)#mpls vpls vpls2000 2000
Hub(config-vpls)# signaling ldp
Hub(config-vpls-sig)# vpls-peer 2.2.2.2
Hub(config-vpls-sig)# exit-signaling
Hub(config-vpls)# exit-vpls
Hub(config)#

```

5. Configure L2-ckt.

```

Hub (config)#mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
Hub (config-pseudowire)#

```

6. Attach L2-ckt under vpls instance.

```

Hub (config)#mpls vpls vpls2000 2000
Hub (config-vpls)#vpls-vc vc2000
Hub(config-vpls-spoke)#

```

Configure H-VPLS on Spoke Router

Follow the steps to configure the H-VPLS on Spoke router:

1. Configure router LDP.


```
Spoke(config)#router ldp
Spoke(config-router)# router-id 8.8.8.8
Spoke(config-router)# transport-address ipv4 8.8.8.8
```
2. Configure targeted-peer under router LDP.


```
Spoke(config-router)# targeted-peer ipv4 5.5.5.5
Spoke(config-router-targeted-peer)# exit-targeted-peer-mode
```
3. Enable LDP and label-switching for core interface.


```
Spoke(config)#interface xe12
Spoke(config-if)# enable-ldp ipv4
Spoke(config-if)#label-switching
```
4. Configure VPLS instance.


```
Spoke(config)#mpls vpls vpls2000 2000
Spoke(config-vpls)#
```
5. Configure L2-ckt.


```
Spoke(config)#mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
Spoke(config-pseudowire)#
```
6. Attach L2-ckt under vpls instance.


```
Spoke (config)#mpls vpls vpls2000 2000
Spoke(config-vpls)#vpls-vc vc2000
Spoke(config-vpls-spoke)#
```
7. Configure sub-interface and attach vpls-instance to sub-interface.


```
Spoke(config)#
Spoke(config)#interface xe26.2000 switchport
Spoke(config-if)# encapsulation dot1q 2000
Spoke(config-if)# access-if-vpls
Spoke(config-acc-if-vpls)# mpls-vpls vpls2000
Spoke(config-acc-if-vpls)#
```

Running Configuration on PE1 Router

```
router ldp
router-id 2.2.2.2
targeted-peer ipv4 5.5.5.5
exit-targeted-peer-mode
transport-address ipv4 2.2.2.2
!
interface xe14
enable-ldp ipv4
!
mpls vpls vpls2000 2000
signaling ldp
vpls-peer 5.5.5.5
exit-signaling
exit-vpls
!
interface xe16.2000 switchport
```

```
access-if-vpls
mpls-vpls vpls2000
```

Running Configuration on Hub Router

```
router ldp
targeted-peer ipv4 2.2.2.2
exit-targeted-peer-mode
targeted-peer ipv4 8.8.8.8
exit-targeted-peer-mode
!
!
mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
!
mpls vpls vpls2000 2000
vpls-vc vc2000
exit-spoke
signaling ldp
vpls-peer 2.2.2.2
exit-signaling
exit-vpls
```

Running Configuration on Spoke Router

```
router ldp
router-id 8.8.8.8
targeted-peer ipv4 5.5.5.5
exit-targeted-peer-mode
transport-address ipv4 8.8.8.8
!
mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
!
mpls vpls vpls2000 2000
vpls-vc vc2000
exit-spoke
exit-vpls
!
interface xe26.2000 switchport
access-if-vpls
mpls-vpls vpls2000
```

Validation

Validate the show output after configuration as shown below.
Verify vpls mesh are up between PE and Hub

```
PE1#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label
Lkps/St	PW-INDEX	SIG-Protocol	Status	UpTime	
2000	5.5.5.5	31364	28162	xe14	26883
2/Up	4	LDP	Active	2d10h36m	

```
Hub#sho mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label
Lkps/St	PW-INDEX	SIG-Protocol	Status	UpTime	
2000	2.2.2.2	29446	26883	xe1	28162
2/Up	3	LDP	Active	2d10h39m	

Verify vpls spoke are up between Hub and Spoke

```
Hub#sho ldp mpls-l2-circuit
Transport Client VC VC Local Remote Destination
Lo-cal Remote
VC ID Binding State Type VC Label VC Label Address
PW Status PW Status
2222 VPLS:2000 UP Ethernet 26882 26886 8.8.8.8
Forwarding Forwarding
```

```
Hub#sho mpls vpls spoke
VPLS-ID Virtual Circuit Tunnel-Label In-Label Network-Intf Out-Label
Lkps/St Secondary
2000 vc2000 29443 26882 ce4 26886
2/Up
---
```

```
Spoke#show ldp mpls-l2-circuit
Transport Client VC VC Local Remote Destination
Lo-cal Remote
VC ID Binding State Type VC Label VC Label Address
PW Status PW Status
2222 VPLS:2000 UP Ethernet 26886 26882 5.5.5.5
Forwarding Forwarding
```

```
Spoke#show mpls vpls spoke
VPLS-ID Virtual Circuit Tunnel-Label In-Label Network-Intf Out-Label
Lkps/St Secondary
2000 vc2000 29440 26886 ce4 26882
2/Up
---
```

Verify H-vpls session on Hub and spoke:

```
Hub#show mpls vpls vpls2000
Virtual Private LAN Service Instance: vpls2000, ID: 2000
SIG-Protocol: LDP
Attachment-Circuit: UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Ignoring AC interface and spoke-VC state
```

```
Configured interfaces:
None
```

```
Mesh Peers:
  2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d10h47m)
  3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d10h56m)
Spoke Peers:
  vc2000 (Up) (UpTime 00:05:48)
```

```
Spoke#show mpls vpls vpls2000
Virtual Private LAN Service Instance: vpls2000, ID: 2000
SIG-Protocol: N/A
Attachment-Circuit: UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, Configured MTU: 1500
Description: none
service-tpid: dot1q
Operating mode: Raw

Configured interfaces:
  Interface: xe26.2000
  Status: Up
  Subinterface Match Criteria(s) :
  dot1q 2000

Spoke Peers:
  vc2000 (Up) (UpTime 00:07:47)
```

Commands for H-VPLS Configuration

The H-VPLS uses the following configuration commands.

vpls-vc

Use this command to add a spoke virtual circuit to VPLS domain hierarchically.

Use `no` parameter of this command to remove this configuration.

Command Syntax

```
vpls-vc NAME
    (secondary NAME|)
    (ethernet|vlan|)
```

Parameters

NAME	Specifies the name of the VPLS. It is a string that identifies the MPLS VC to add to the VPLS domain.
secondary	Specifies the name of the secondary spoke.
NAME	Specifies the name for the secondary spoke.
ethernet	Specifies the spoke type. Defaults to <code>ethernet</code> .
vlan	Specifies the spoke type.

Default

Disabled

Command Mode

VPLS mode

Applicability

Introduced before OcNOS version 1.3.

Modified the command prompt into a hierarchical structure from single line in the OcNOS version 6.5.1.

Example

Example for adding a spoke virtual circuit with VPLS name vc1 and secondary spoke vc2:

```
#configure terminal
(config)#mpls vpls vpls1 3000
(config-vpls)#vpls-vc vc1
(config-vpls-spoke)#secondary vc2
(config-vpls-spoke)#type ethernet
(config-vpls-spoke)#exit-spoke
(config-vpls)#exit
```

Example to remove the configuration of the spoke virtual circuit with VPLS name vc1:

```
#configure terminal
(config)#mpls vpls vpls1 3000
(config-vpls)#no vpls-vc vc1
(config-vpls)#exit
```

signaling

Use this command to set all mesh and spoke pseudowires to down when all access interfaces are down.

Use `ignore-ac-spoke-state` parameter of this command to remove this configuration.

Command Syntax

```
signaling ldp block-mesh-spoke-on-all-ac-down
signaling ignore-ac-spoke-state
```

Parameters

block-mesh-spoke-on-all-ac-down	(Optional) Controls the behavior of pseudowires (PWs) in a VPLS instance when all access interfaces associated with the VPLS instance are down.
ignore-ac-spoke-state	Ignores access interfaces and spoke pseudowires state and keep mesh pseudowires up.

Default

disabled

Command Mode

VPLS mode

Applicability

Introduced before OcNOS version 1.3.

Modified the command prompt into a hierarchical structure from single line in the OcNOS version 6.5.1.

Example

Example for setting up all mesh and spoke pseudowires to down when all access interfaces are down:

```
#configure terminal
(config)# mpls vpls test 100
(config-vpls)#signaling ldp
(config-vpls-sig)#block-mesh-spoke-on-all-ac-down
(config-vpls-sig)#exit
```

Example for setting up all mesh and spoke pseudowires to up:

```
#configure terminal
(config)# mpls vpls test 100
(config-vpls)#signaling ldp
(config-vpls-sig)#ignore-ac-spoke-state
(config-vpls-sig)#exit
```

CHAPTER 10 Virtual Private Wire Service Configuration

This chapter shows configurations for Virtual Private Wire Service (VPWS), where a point-to-point Layer 2 VPN service interconnects multiple Ethernet LANs across an MPLS backbone.

Overview

An MPLS Layer 2 Virtual Circuit (VC) is a point-to-point Layer 2 connection transported via MPLS on the service provider's network. The Layer 2 circuit is transported over a single Label Switched Path (LSP) tunnel between two Provider Edge (PE) routers.

The following diagram illustrates the configuration steps in this section. In this sample, the VC host devices, Host1 and Host2, are connected to the Provider Edge (PE) router PE-1; and Host3 and Host4 are connected to PE-2. The VC is established between PE-1 and PE-2. Interface xe2, on PE-1 and PE-2, is connected to the customer network; xe1, on PE-1 and PE-2, is connected to the MPLS cloud.

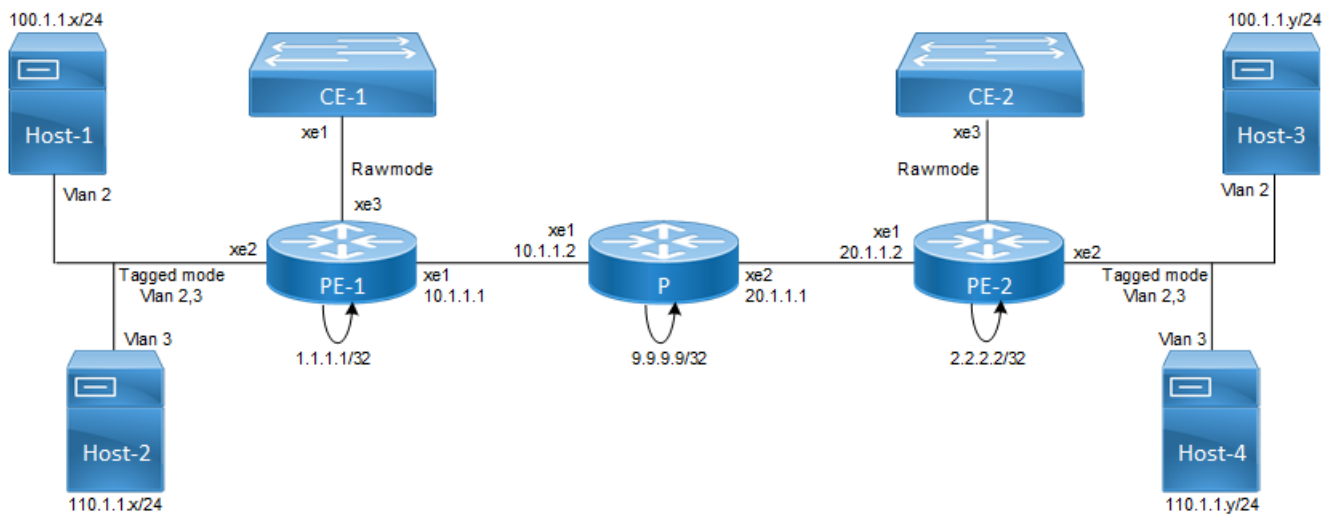


Figure 10-26: MPLS Layer 2 Virtual Circuit

The VC configuration process can be divided into the following steps:

Note: Loopback addresses being used should be advertised through OSPF, or should be statically routed.

1. Configure the IP address and OSPF for the PE-1, P (Provider), and PE-2 routers.
2. Configure MPLS and LDP on PE-1, P, and PE-2, and LDP targeted peer for the PE-1 and PE-2 routers. (If RSVP is used for configuring trunks, LDP must be configured on PE-1 and PE-2, and RSVP must be configured on PE-1, P, and PE-2.)
3. Configure the VC.
4. Bind the customer interface to the VC.

Configure IP Address and OSPF on Routers

Configure the IP addresses and OSPF on the PE-1, P, and PE-2 routers.

PE-1

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback interface (lo0) to be configured.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.1.1.1/24	Set the IP address of the interface to 10.1.1.1/24.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.1.1.0/24 area 0 (config-router)#network 1.1.1.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

P

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback interface (lo0) to be configured.
(config-if)#ip address 9.9.9.9/32 secondary	Set the IP address of the loopback interface to 9.9.9.9/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.1.1.2/24	Set the IP address of the interface to 10.1.1.2/24.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#ip address 20.1.1.1/24	Set the IP address of the interface to 20.1.1.1/24.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.1.1.0/24 area 0 (config-router)#network 20.1.1.0/24 area 0 (config-router)#network 9.9.9.9/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

PE-2

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback interface (lo0) to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if)#exit	Exit interface mode.

(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 20.1.1.2/24	Set the IP address of the interface to 20.1.1.2/24.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 20.1.1.0/24 area 0 (config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs, and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

Configure MPLS, LDP, and LDP Targeted Peer on Routers

Configure MPLS and LDP on PE-1, P, and PE-2, and LDP targeted peers on PE-1 and PE-2.

Note: If RSVP is used for configuring trunks, LDP must be configured on PE-1 and PE-2, and RSVP must be configured on PE-1, P, and PE-2,

PE-1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 2.2.2.2	Specify the targeted LDP peer on PE-1.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the Router mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1..
(config-if)#commit	Commit the transaction.

P

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)#router-id 9.9.9.9	Set the router ID to IP address 9.9.9.9
(config-router)#transport-address ipv4 9.9.9.9	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#exit	Exit the Router mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.

(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe2.
(config-if)#commit	Commit the transaction.

PE-2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 1.1.1.1	Specify the targeted LDP peer on PE-2.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the Router mode.
(config)#interface xe1	Specify the interface(xe1) to be configured.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config-if)#commit	Commit the transaction.

Configure VC

Configure the VC. Each VC ID uniquely identifies the Layer-2 circuit among all the Layer-2 circuits.

Note: Both PE routers (endpoints) must be configured with the same VC-ID (100 in this example).

PE-1

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t1 100 2.2.2.2	Configure the VC for PE-2. In this example, t1 is the VC name, 100 is the VC ID, and 2.2.2.2 is the VC endpoint IP address.
(config)#commit	Save transaction into the database

PE-2

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t1 100 1.1.1.1	Configure the VC for PE-1. In this example, t1 is the VC name, 100 is the VC ID, and 1.1.1.1 is the VC endpoint IP address.
(config)#commit	Commit the transaction.

Bind Customer Interface to VC

Bind the customer interface to the VC using one of the two procedures described below: Layer-2 untagged traffic or Layer-2 tagged traffic.

Note: Layer 2 VCs can only be bound to Layer 2 interfaces. The VC encapsulation method should be Ethernet (default), VLAN.

Layer 2 Untagged Traffic

Use Access mode for Layer 2 untagged traffic.

PE-1

#configure terminal	Enter configure mode.
(config)#service-template SUT1	Create a service template SUT1
(config-svc)#match untagged	Allow untagged traffic.
(config-svc)#exit	Exit the service template mode
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#mpls-l2-circuit t1 service-template SUT1	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.

PE-2

#configure terminal	Enter configure mode.
(config)#service-template SUT1	Create a service template SUT1
(config-svc)#match untagged	Allow untagged traffic.
(config-svc)#exit	Exit the service template mode
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#mpls-l2-circuit t1 service-template SUT1	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.

Layer 2 Tagged Traffic

Use Trunk mode for Layer-2 tagged traffic. The following configuration allows only VLAN 2 and 3 traffic.

PE-1

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t2 200 2.2.2.2	Configure the VC for PE-2. In this example, t2 is the VC name, 200 is the VC ID, and 2.2.2.2 is the VC endpoint IP address.
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#service-template ST1	Create a service template ST1
(config-svc)#match outer-vlan 2	Allow VLAN 2 traffic on this VC.
(config-svc)#match outer-vlan 3	Allow VLAN 3 traffic on this VC.

(config-svc)#exit	Exit the service template mode
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#mpls-l2-circuit t2 service-template ST1	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.

PE-2

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t2 200 1.1.1.1	Configure the VC for PE-2. In this example, t2 is the VC name, 200 is the VC ID, and 1.1.1.1 is the VC endpoint IP address.
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#service-template ST1	Create a service template ST1
(config-svc)#match outer-vlan 2	Allow VLAN 2 traffic on this VC.
(config-svc)#match outer-vlan 3	Allow VLAN 3 traffic on this VC.
(config-svc)#exit	Exit the service template mode
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#mpls-l2-circuit t2 service-template ST1	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.

Validation

Use the show ldp mpls-l2-circuit (Control Plane) command, and the show mpls vc-table (Forwarding Plane) command, to display complete information about the Layer 2 VC.

If the VC State is UP in the output from the show ldp mpls-l2 circuit command, and the Status is Active in the output of the show mpls vc-table command, a ping from CE1 to CE2 should be successful.

```
#show ldp mpls-l2-circuit
```

Transport	Client	VC	Trans	Local	Remote	Destination
VC ID	Binding	State	Type	VC Label	VC Label	Address
100	xe3	UP	Ethernet	VLAN 26240	26240	2.2.2.2
200	xe2	UP	Ethernet	VLAN 26241	26241	2.2.2.2

```
#show mpls vc-table
```

```
(m) - Service mapped over multipath transport
```

```
(e) - Service mapped over LDP ECMP
```

VC-ID	Vlan-ID	Inner-Vlan-ID	Access-Intf	Network-Intf	Out Label	Tunnel-Label
Nexthop	Status					
100	N/A	N/A	xe3	xe1	26240	25600
2.2.2.2	Active					
200	N/A	N/A	xe2	xe1	26241	25600
2.2.2.2	Active					


```
PE2#show ldp mpls-l2-circuit
```

Transport	Client	VC	VC	Local	Remote	Destination
VC ID	Binding	State	Type	VC Label	VC Label	Address
100	xe3	UP	Ethernet	VLAN 26240	26240	1.1.1.1
200	xe2	UP	Ethernet	VLAN 26241	26241	1.1.1.1

```
PE2#sh mpls vc-table
```

```
(m) - Service mapped over multipath transport
```

```
(e) - Service mapped over LDP ECMP
```

```
VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label Tunnel-Label Nexthop Status
100 N/A N/A xe3 xe1 26240 25601 1.1.1.1 Active 200 N/A N/A xe2 xe1 26241 25601 1.1.1.1 Active
```

```
PE1#show ldp mpls-l2-circuit
```

Transport	Client	VC	VC	Local	Remote	Destination
VC ID	Binding	State	Type	VC Label	VC Label	Address
100	xe3	UP	Ethernet	VLAN 26240	26240	2.2.2.2
200	xe2	UP	Ethernet	VLAN 26241	26241	2.2.2.2

```
PE1#show mpls vc-table
```

```
(m) - Service mapped over multipath transport
```

```
(e) - Service mapped over LDP ECMP
```

```
VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label Tunnel-Label Nexthop Status
100 N/A N/A xe3 xe1 26240 25600 2.2.2.2 Active 200 N/A N/A xe2 xe1 26241 25600 2.2.2.2 Active
```

```
PE2#show ldp mpls-l2-circuit
```

Transport	Client	VC	VC	Local	Remote	Destination
VC ID	Binding	State	Type	VC Label	VC Label	Address
100	xe3	UP	Ethernet	VLAN 26240	26240	1.1.1.1
200	xe2	UP	Ethernet	VLAN 26241	26241	1.1.1.1

```
PE2#show mpls vc-table
```

```
(m) - Service mapped over multipath transport
```

```
(e) - Service mapped over LDP ECMP
```

```
VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label Tunnel-Label Nexthop Status
100 N/A N/A xe3 xe1 26240 25601 1.1.1.1 Active 200 N/A N/A xe2 xe1 26241 25601 1.1.1.1 Active
```

These additional commands can also be used to display information about the Layer 2 virtual circuits.

```
show ldp mpls-l2-circuit detail
```

```
show ldp mpls-l2-circuit VC-ID
```

```
show ldp mpls-l2-circuit VC-ID detail
```

```
show mpls l2-circuit
```

PE1

```
PE1#show ldp mpls-l2-circuit detail
```

```
PW ID: 100, VC state is up
```

```
Access IF: xe3,up,AC state is up
```

```
Session IF: xe1, state is up
```

```
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
```

```
Local vctype: vlan, remote vctype :vlan
```

```
Local groupid: 0, remote groupid: 0
```

```
Local label: 26240, remote label: 26240
```

```
Local MTU: 1500, Remote MTU: 1500
```

```
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow
```

Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:03:19

PW ID: 200, VC state is up
Access IF: xe2,up,AC state is up
Session IF: xe1, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26241, remote label: 26241
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:01:16

```
PE1#show ldp mpls-12-circuit 100
```

Transport	Client	VC	VC	Local	Remote	Destination
VC ID	Binding	State	Type	VC Label	VC Label	Address
100	xe3	UP	Ethernet	VLAN 26240	26240	2.2.2.2

```
PE1#show ldp mpls-12-circuit 200
```

Transport	Client	VC	VC	Local	Remote	Destination
VC ID	Binding	State	Type	VC Label	VC Label	Address
200	xe2	UP	Ethernet	VLAN 26241	26241	2.2.2.2

```
PE1#show ldp mpls-12-circuit
100 detail PW ID: 100, VC state is up
Access IF: xe3,up,AC state is up
Session IF: xe1, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26240, remote label: 26240
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:04:19
```

```
PE1#show ldp mpls-12-circuit 200 detail
```

```
PW ID: 200, VC state is up
Access IF: xe2,up,AC state is up
Session IF: xe1, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26241, remote label: 26241
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow
Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled MPLS VC UpTime : 00:02:24
```

```
PE1#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: t1, id: 100 PW-INDEX: 1 service-tpid: dot1.q
Endpoint: 2.2.2.2
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe3
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : SUT1
Match criteria : Untagged
```

```
MPLS Layer-2 Virtual Circuit: t2, id: 200 PW-INDEX: 2 service-tpid: dot1.q
Endpoint: 2.2.2.2
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe2
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST1
Match criteria : 2,3
```

PE2

```
PE2#show ldp mpls-l2-circuit detail
PW ID: 100, VC state is up
Access IF: xe3,up,AC state is up
Session IF: xe1, state is up
Destination: 1.1.1.1, Peer LDP Ident: 10.143.73.1
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
```

Local label: 26240, remote label: 26240
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled MPLS VC UpTime : 00:07:08

PW ID: 200, VC state is up
Access IF: xe2,up,AC state is up
Session IF: xe1, state is up
Destination: 1.1.1.1, Peer LDP Ident: 10.143.73.1
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26241, remote label: 26241
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:05:05

PE2#show ldp mpls-l2-circuit 100

Transport	Client	VC	VC	Local	Remote	Destination
VC ID	Binding	State	Type	VC Label	VC Label	Address
100	xe3	UP	Ethernet VLAN	26240	26240	1.1.1.1

PE2#show ldp mpls-l2-circuit 200

Transport	Client	VC	VC	Local	Remote	Destination
VC ID	Binding	State	Type	VC Label	VC Label	Address
200	xe2	UP	Ethernet VLAN	26241	26241	1.1.1.1

PE2#show ldp mpls-l2-circuit

PW ID: 200, VC state is up
Access IF: xe2,up,AC state is up
Session IF: xe1, state is up
Destination: 1.1.1.1, Peer LDP Ident: 10.143.73.1
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26241, remote label: 26241
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:06:00

```

PE2#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: t1, id: 100 PW-INDEX: 1 service-tpid: dot1.q
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe3
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : SUT1
Match criteria : Untagged

MPLS Layer-2 Virtual Circuit: t2, id: 200 PW-INDEX: 2 service-tpid: dot1.q
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe2
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST1
Match criteria : 2,3

```

Configure a Static Layer-2 VC

For a static MPLS Layer 2 VC configuration:

1. Configure the VC with the manual option
2. Configure the VC FIB entry
3. Bind the VC; all steps are in the configurations that follow.

PE-1

#configure terminal	Enter configure mode.
PE1(config)#mpls l2-circuit t3 300 2.2.2.2	Configure the VC ID for PE1
PE1(config-pseudowire)#manual-pseudowire	Configure pseudowire manual (no signaling)
PE1(config-pseudowire)#exit	Exit pseudowire config mode.
PE1(config)#service-template ST3	Create a service template ST3
PE1(config-svc)#exit	Exit the service template mode
PE1(config)#interface xe2	Add an FTN entry; where 1000 is the incoming label, 2000 is the outgoing label, 2.2.2.2 is the endpoint, xe1 is the incoming interface name, and xe2 is outgoing interface name.

PE1(config)#switchport	config interface as switch port.
PE1(config-if)#mpls-l2-circuit t3 service-template ST3	Bind the interface to the VC with service template.
PE1(config-if)#exit	Exit interface mode
PE1(config)#mpls l2-circuit-fib-entry 300 1000 2000 2.2.2.2 xe1 xe2	Configure the VC ID with the manual option (no signaling used).
PE1(config)#commit	Commit the transaction.

PE-2

#configure terminal	Enter configure mode.
PE2(config)#mpls l2-circuit t3 300 1.1.1.1	Configure the VC ID for PE2
PE2(config-pseudowire)#manual-pseudowire	Configure pseudowire manual (no signaling)
PE2(config-pseudowire)#exit	Exit pseudowire config mode.
PE2(config)#service-template ST3	Create a service template ST3
(config-svc)#exit	Exit the service template mode
PE2(config)#interface xe2	Add an FTN entry; where 2000 is the incoming label, 1000 is the outgoing label, 1.1.1.1 is the endpoint, xe1 is the incoming interface name, and xe 2 is outgoing interface name.
PE1(config)#switchport	config interface as switch port.
PE2(config-if)#mpls-l2-circuit t3 service-template ST3	Bind the interface to the VC with service template.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#mpls l2-circuit-fib-entry 300 2000 1000 1.1.1.1 xe1 xe2	Configure the VC ID with the manual option (no signaling used).
PE2(config)#end	Exit configure mode.
PE2(config)#commit	Commit the transaction.

Validation

This example shows number of configured VCs and its status.

```
#show mpls vc-table count
```

```
-----
Num PWs      : 3
Active PWs   : 3
OAM-only PWs : 0
Inactive PWs : 0
-----
```

```
#show ldp mpls-l2-circuit count
```

```
-----
Num Signaled PWs: 3          [UP: 3]
-----
```

Service Template Configuration

PE-1

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit vc1 10 2.2.2.2	Configure the VC
(config-pseudowire)# service-tpid dot1.ad	Configure Service-TPID as dot1.ad (0x88a8)
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)# service-template template1	Configure the service template.
(config-svc)# match double-tag outer-vlan 204 inner-vlan 203	Matching criteria for service template.
(config-svc)#rewrite ingress pop outgoing- tpid dot1.ad	Action performed for service template.
(config-svc)#exit	Exit configure SVC mode
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#dot1ad ethertype 0x88a8	Configure interface ethertype as dot1.ad (0x88a8)
(config-if)#mpls-l2-circuit vc1 service- template template1	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.
(config-if)#end	End of Interface and configurations mode.

PE-2

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit vc1 10 1.1.1.1	Configure the VC.
(config-pseudowire)#service-tpid dot1.ad	Configure Service-TPID as dot1.ad (0x88a8)
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)# service-template template1	Configure the service template.
(config-svc)# match double-tag outer-vlan 204 inner-vlan 203	Matching criteria for service template.
(config-svc)# rewrite ingress pop outgoing- tpid dot1.ad	Action performed for service template.
(config-svc)#exit	Exit configure SVC mode
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#dot1ad ethertype 0x88a8	Configure interface ethertype as dot1.ad (0x88a8)
(config-if)#mpls-l2-circuit vc1 service- template template1	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.
(config-if)#end	End of interface and configurations mode.

Validation

PE1

```
PE1#show ldp mpls-l2-circuit detail
PW ID: 10, VC state is up
Access IF: xe2,up,AC state is up
Session IF: xe1, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 24322, remote label: 52482
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current
use: disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
```

```
PE1#show mpls l2-circuit detail
MPLS Layer-2 Virtual Circuit: vc1, id: 10 PW-INDEX: 1 service-tpid: dot1.ad
Endpoint: 2.2.2.2
Control Word: 0
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe2
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : template1
Match criteria : 204/203
Action type : Pop
Outgoing tpid : dot1.ad
```

```
PE1#show mpls vc-table
VC-ID      Vlan-ID  Inner-Vlan-ID  Access-Intf  Network-Intf  Out Label
Tunnel-Label Nexthop      Status
10         N/A        N/A            xe2           xe1            52482
52480      2.2.2.2    Active
```

Service Template with Multiple Match

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

PE-1

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t4 400 2.2.2.2	Configure the VC for PE-1. In this example, t4 is the VC name, 400 is the VC ID, and 2.2.2.2 is the VC endpoint IP address.
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#mpls-l2-circuit t4 service-template template4	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.

PE-2

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t4 400 1.1.1.1	Configure the VC for PE-2. In this example, t4 is the VC name, 400 is the VC ID, and 1.1.1.1 is the VC endpoint IP address.
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#mpls-l2-circuit t4 service-template template4	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.

Validation

```

PE1#show ldp mpls-l2-circuit detail
PW ID: 400, VC state is up
Access IF: xe2,up,AC state is up
Session IF: xe1, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 24324, remote label: 52485
Local MTU: 1500, Remote MTU: 1500

```

Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled

PE1#show mpls l2-circuit detail
MPLS Layer-2 Virtual Circuit: t4, id: 400 PW-INDEX: 4 service-tpid: dot1.q

Endpoint: 2.2.2.2
Control Word: 0
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe2
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : template4
Match criteria : 700
1200/3200
untagged
Action type : Push
Action value : 300

PE1#show mpls vc-table									
VC-ID	Vlan-ID	Inner-Vlan-ID	Access-Intf	Network-Intf	Out Label	Tunnel-Label	Nexthop	Status	Ecmp-Group
400	N/A	N/A	xe2	xe1	24322	24320	2.2.2.2	Active	N/A

PE2#show mpls vc-table									
VC-ID	Vlan-ID	Inner-Vlan-ID	Access-Intf	Network-Intf	Out Label	Tunnel-Label	Nexthop	Status	Ecmp-Group
400	N/A	N/A	xe2	xe1	24321	24325	1.1.1.1	Active	N/A

VPWS-CFM

The below examples contains of Ethernet Operations and Management (OAM) configurations using the Connectivity Fault Management (CFM) protocol.

Connectivity Fault Management detects, verifies, isolates and notifies connectivity failures on a Virtual Bridged LAN (B-VLAN) based on the protocol standard specified in IEEE 802.1ag 2007. It provides discovery and verification of paths through 802.1 bridges and LANs and is part of the Operation, Administration and Management (OAM) module. CFM is transparent to customer data being transported by a network and is capable of providing maximum fault management.

Prerequisite

Configure basic VPWS configuration as in above section.

1. Configure the IP address and OSPF for the PE-1, P (Provider), and PE-2 routers.
2. Configure MPLS and LDP on PE-1, P, and PE-2, and LDP targeted peer for the PE-1 and PE-2 routers. (If RSVP is used for configuring trunks, LDP must be configured on PE-1 and PE-2, and RSVP must be configured on PE-1, P, and PE-2.)

PE1

PE1#configure terminal	Enter configure mode.
PE1(config)#ethernet cfm domain-type character-string domain-name MD-05 level 0 mip-creation none	Create cfm domain with type as character string and set mip creation criteria to default.

PE1(config-ether-cfm)#service ma-type string ma-name CFM-2	Create ma type as string and configure the ma
PE1(config-ether-cfm-ma)# vpws vc1	Configure vpws to associate to the MA
PE1(config-ether-cfm-ma)# ethernet cfm mep up mpid 115 active true vpws vc1	Create mep up on vpws.
PE1(config-ether-cfm-ma-mep)#cc multicast state enable	Enable cc multicast.
PE1(config-ether-cfm-ma-mep)#exit-ether-ma- mep-mode	Exit CFM MEP configuration mode.
PE1(config-ether-cfm-ma)#mep crosscheck mpid 1115	Configure crosscheck to remote MEP.
PE1(config-ether-cfm-ma)#cc interval 10ms	Enable cc interval for 10 millisecond.
PE1(config-ether-cfm-ma)#exit-ether-ma-mode	Exit CFM MA configuration mode.
PE1(config-ether-cfm)#exit	Exit ethernet CFM mode.
PE1(config)#commit	Commit the configuration
PE1(config)#exit	Exit the configure terminal mode

PE2

PE2#configure terminal	Enter configure mode.
PE2(config)#ethernet cfm domain-type character-string domain-name MD-05 level 0 mip-creation none	Create cfm domain with type as character string and set mip creation criteria to default.
PE2(config-ether-cfm)#service ma-type string ma-name CFM-2	Create ma type as string and set mip creation criteria to default.
PE2(config-ether-cfm-ma)#vpws vc1	Configure vpws to associate to the MA
PE2(config-ether-cfm-ma)#ethernet cfm mep down mpid 1115 active true vpws vc1	Create mep up on vpws.
PE2(config-ether-cfm-ma-mep)#cc multicast state enable	Enable cc multicast.
PE2(config-ether-cfm-ma-mep)#exit-ether-ma- mep-mode	Exit CFM MEP configuration mode
PE2(config-ether-cfm-ma)#mep crosscheck mpid 115	Configure crosscheck to remote MEP in VLAN 512.
PE2(config-ether-cfm-ma)#cc interval 10ms	Enable cc interval for 10 millisecond.
PE2(config-ether-cfm-ma)#exit-ether-ma-mode	Exit CFM MA configuration mode.
PE2(config-ether-cfm)#exit	Exit ethernet CFM mode.
PE2(config)#commit	Commit the configuration
PE2(config)#exit	Exit the configure terminal mode

Validation

PE1

```
PE1#show ethernet cfm statistics
Continuity Check Messages
```

```
CCM Sent           : 4378
CCM Received        : 0
```

Loop Back Messages

```
LBM Sent           : 5
LBR Received(Valid) : 5
LBR Received(Bad msdu) : 0
LBR Received(Out-of-Seq) : 0
```

Link Trace Messages

```
LTM Sent           : 2
LTR Sent           : 0
LTR Received(Valid) : 2
LTR Received(unexpected) : 0
```

```
PE1#show ethernet cfm maintenance-points local mep domain MD-05 ma-name CFM-2
MPID Dir Lvl CC-Stat HW-Status  CC-Intvl MAC-Address  Def Port  MD Name
```

```
-----
115 Up 0 Enable Installed 100 ms b86a.97db.2eca F xe4 MD-05
```

```
PE1#show ethernet cfm maintenance-points remote domain MD-05 ma-name CFM-2
```

```
MEPID RMEPID LEVEL Rx CCM RDI PEER-MAC TYPE
-----
115 1115 0 Yes False f88e.a192.4436 Configured
```

```
PE1#show ethernet cfm ma status domain MD-05 ma-name CFM-2
```

```
MA NAME STATUS
-----
CFM-2 Active
```

```
PE1#show ethernet cfm maintenance-points remote domain MD-05 ma-name CFM-2
```

```
MEPID RMEPID LEVEL Rx CCM RDI PEER-MAC TYPE
-----
115 1115 0 Yes False f88e.a192.4436 Configured
```

```
PE1#ping ethernet mac f88e.a192.4436 unicast source 115 domain MD-05 ma CFM-2
success rate is 100 (5/5)
```

```
PE1#traceroute ethernet f88e.a192.4436 mepid 115 domain MD-05 ma CFM-2
```

```
MP Mac Hops Relay-action Ingress/Egress Ingress/Egress action
f88e.a192.4436 1 RlyHit Ingress IngOK
```

PE2

```
PE2#show ethernet cfm statistics
```

Continuity Check Messages

```
CCM Sent           : 8841
CCM Received        : 0
```

Loop Back Messages

```
LBM Sent : 5
LBR Received(Valid) : 5
LBR Received(Bad msdu) : 0
LBR Received(Out-of-Seq): 0
```

Link Trace Messages

```
LTM Sent : 1
LTR Sent : 2
LTR Received(Valid) : 1
LTR Received(unexpected): 0
```

```
PE2#show ethernet cfm maintenance-points local mep domain MD-05 ma-name CFM-2
```

MPID	Dir	Lvl	CC-Stat	HW-Status	CC-Intvl	MAC-Address	Def Port	MD Name
1115	Up	0	Enable	Installed	100 ms	f88e.a192.4436 F	xe19	MD-05

```
PE2#show ethernet cfm maintenance-points remote domain MD-05 ma-name CFM-2
```

MEPID	RMEPID	LEVEL	Rx CCM	RDI	PEER-MAC	TYPE
1115	115	0	Yes	False	b86a.97db.2eca	Configured

```
PE2#show ethernet cfm ma status domain MD-05 ma-name CFM-2
```

MA NAME	STATUS
CFM-2	Active

```
PE2#show ethernet cfm maintenance-points remote domain MD-05 ma-name CFM-2
```

MEPID	RMEPID	LEVEL	Rx CCM	RDI	PEER-MAC	TYPE
1115	115	0	Yes	False	b86a.97db.2eca	Configured

```
PE2#ping ethernet mac b86a.97db.2eca unicast source 1115 domain MD-05 ma CFM-2
success rate is 100 (5/5)
```

```
PE2#traceroute ethernet b86a.97db.2eca mepid 1115 domain MD-05 ma CFM-2
```

MP Mac	Hops	Relay-action	Ingress/Egress	Ingress/Egress action
b86a.97db.2eca	1	RlyHit	Ingress	IngOK

Layer 3 Virtual Private network Configuration

CHAPTER 1 L3VPN over EVPN MPLS Configuration

This chapter includes step-by-step configurations for L3VPN over EVPN MPLS.

Overview

L3vpn EVPN MPLS ensures that we are able to do the Ip-vrf to Ip-vrf routing with MPLS as overlay. We can ensure that with this model we can do the Anycast gateway using EVPN concepts. L3VPN EVPN MPLS is a way of integrating the interface-less model. In this model we will use non-irb interface i.e. L3 interface for the Ip-Vrf routing.

Using Anycast gateway idea is to have the Multi-Homed PE nodes to work in active-standby mode. From remote perspective at one time only one Peer PE will be active. If that PE goes down, then a new tunnel to the peer PE will be established for the traffic. From the access-side Traffic can reach to either of the peer PE and sent across the remote PE nodes. This way we can achieve redundancy using the anycast mac-address.

Topology

Below Topology depicts the topology for the L3VPN over EVPN MPLS configuration examples for both single homing and multi-homing with SR/LDP. MLAG configured between PE1 and PE2 to achieve multi-homing Active-Standby connected to CE1.

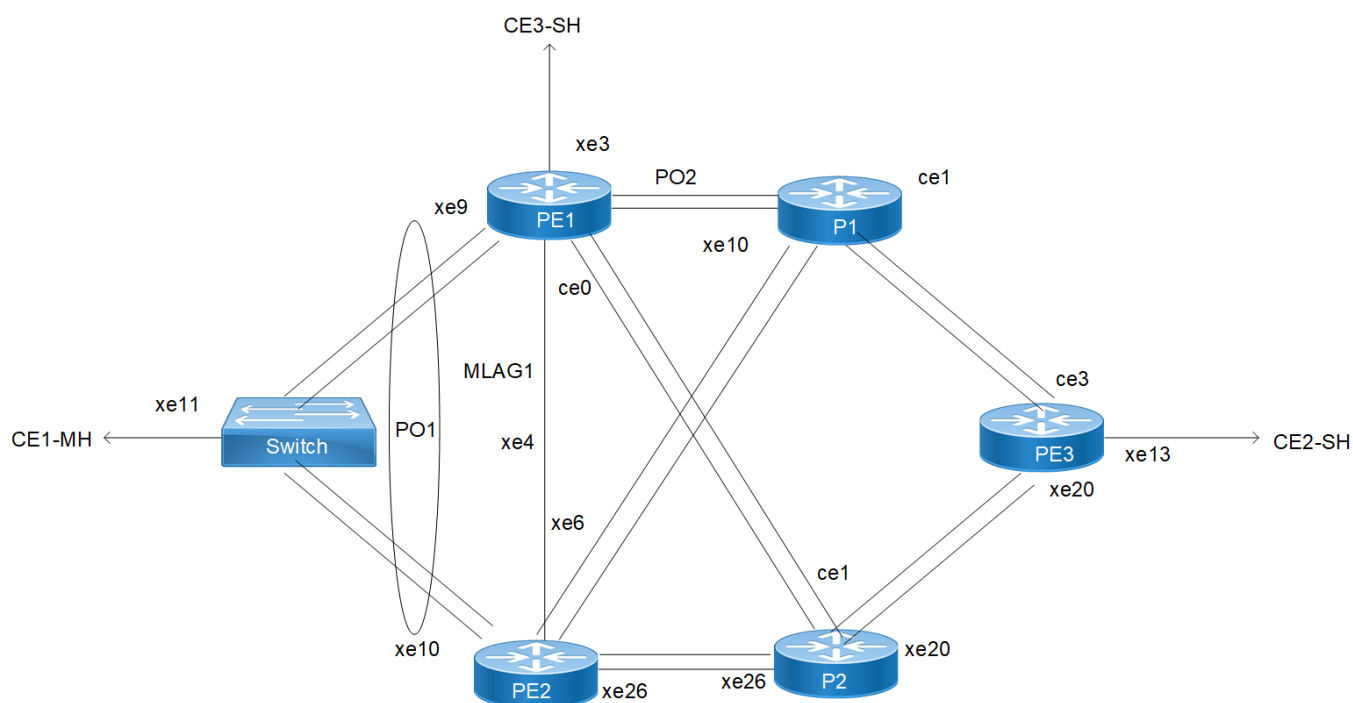


Figure 1-27: Topology diagram for L3VPN over EVPN MPLS

Configuration

PE1

Loopback Interface:

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 1.1.1.1/32 secondary	Configure IP address on loopback interface.
(config-if)# prefix-sid index 1	Configuring prefix sid for segment id
(config-if)#commit	Commit the transaction.
(config-if)#exit	Exit interface mode

Global EVPN MPLS Command:

#configure terminal	Enter configuration mode.
(config)#load-balance enable	Enable Load balance
(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware profile for evpn mpls multihoming
(config)#evpn mpls enable	Enable EVPN MPLS
(config)#evpn mpls irb	Enable EVPN MPLS IRB
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming
(config)#evpn mpls vtep-ip-global 1.1.1.1	Configuring VTEP global IP to loopback IP
(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.4466	Configuring anycast gateway mac for MH. Note: Anycast gateway is mandatory for MH nodes.
(config)#commit	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature.

Configure SR:

(config)#segment-routing	Configure segment routing
(config-sr)# mpls sr-prefer	Set mpls prefer segment routing over other protocols
(config-sr)#exit	Exit from router sr mode
(config)#commit	Commit the transaction.

Configure LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)# transport-address ipv4 1.1.1.1	Configuring transport address
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

MLAG Configuration:

(config)#interface mlag1	Create mlag interface
(config-if)# switchport	Configuring as L2 port
(config-if)# load-interval 30	Configure load interval
(config-if)# exit	Exit from interface mode
(config)#interface po1	Configure dynamic lag
(config-if)# switchport	Configuring as L2 port
(config-if)# mtu 1500	Set mtu value
(config-if)# mlag 1	Attach mlag to po1. Note: While creating po1 subifp, this needs to be un-configured and configured back
(config-if)#interface xe10	Enter interface mode for xe10
(config-if)# channel-group 1 mode active	Attach lag interface po1
(config-if)#exit	Exit interface mode
(config)#mcec domain configuration	Create mcec domain
(config-mcec-domain)# domain-address 1111.2222.3333	Configure mcec domain address
(config-mcec-domain)# domain-system-number 1	Configure system number. Active node should have lower value.
(config-mcec-domain)# intra-domain-link xe4	Configure ideal interface between mlag devices
(config-mcec-domain)# domain-hello-timeout long	Configure domain hello timeout

Interface Configuration Network Side:

(config-if)#interface ce0	Configure network interface ce0
(config-if)# ip address 20.1.1.1/24	Configure IP address on the interface.
(config-if)# mtu 1522	Configure mtu
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# mpls ldp-igp sync ospf	Configure mpls igp sync
(config-if)# ip ospf network point-to-point	Configure ospf as p2p
(config-if)# enable-ldp ipv4	Enable LDP on the physical interface
(config)#interface po2	Create channel group po2
(config-if)# ip address 10.1.1.1/24	Configure IP address on the interface.
(config-if)# mtu 2000	Configure mtu
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# mpls ldp-igp sync ospf	Configure mpls igp sync
(config-if)# ip ospf network point-to-point	Configure ospf as p2p
(config-if)# enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#interface xe18	Enter interface mode for xe18
(config-if)# channel-group 2 mode active	Attach lag interface po2
(config-if)#interface xe19	Enter interface mode for xe19

(config-if)# channel-group 2 mode active	Attach lag interface po2
(config)#commit	Commit the transaction.

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# network 1.1.1.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 20.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# ospf segment-routing global block 16000 23000	Configure SR global block for ospf
(config-router)# segment-routing mpls	Enable ospf SR
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

BGP Configuration:

(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 5.5.5.5 remote-as 100	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 fall-over bfd multihop	Configure BFD
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Enter in to address family ipv4 unicast mode
(config-router-af)# neighbor 5.5.5.5 activate	Activate PE3 neighbor
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family l2vpn evpn	Enter in to address family l2vpn vpn
(config-router-af)# neighbor 5.5.5.5 activate	Activate PE3 neighbor
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 unicast	Enter in to address family ipv6 unicast mode
(config-router-af)# neighbor 5.5.5.5 activate	Activate PE3 neighbor
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv4 vrf vrf102	Enter in to address family ipv4 vrf vrf102
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv4 vrf vrf101	Enter in to address family ipv4 vrf vrf102
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp

(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 vrf vrf101	Enter in to address family ipv6 vrf vrf101
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 vrf vrf102	Enter in to address family ipv6 vrf vrf102
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family

IP VRF Configuration:

(config-vrf)#ip vrf vrf102	Enter VRF mode
(config-vrf)# rd 10001:102	Configuring Route-Distinguisher value
(config-vrf)# route-target both 1.1.1.1:102	Configure RT value
(config-vrf)# l3vni 102	Configure L3VNID to populate route through evpn
(config-vrf)#ip vrf vrf101	Enter VRF mode
(config-vrf)# rd 10001:1	Configuring Route-Distinguisher value
(config-vrf)# route-target both 1.1.1.1:1	Configure RT value
(config-vrf)# l3vni 101	Configure L3VNID to populate route through evpn

L3 VRF Port Configuration:

(config-if)#interface xe3	Enter the Interface mode for xe3. This is for untagged traffic
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 100.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 1000::1/64	Assign ipv6 address
(config-if)#interface xe3.1	Create xe3.1 subifp
(config-if)# encapsulation dot1q 10	Configure encapsulation as single tagged
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 110.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 1100::1/64	Assign ipv6 address
(config-if)#interface xe3.2	Create xe3.2 subifp
(config-if)# encapsulation dot1q 11 inner-dot1q 11	Configure encapsulation as double tagged
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 120.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 1200::1/64	Assign ipv6 address
(config-if)#interface xe3.11	Create xe3.11 subifp
(config-if)# encapsulation dot1q 11	Configure encapsulation as single tagged
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 111.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 1110::1/64	Assign ipv6 address

(config-if)#interface po1.11	Create po1 subinterface. We need to unconfigure mlag under po1 before creating subinterface.
(config-if)# encapsulation dot1q 11	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac
(config-if)# ip address 150.11.1.1/24	Assign ipv4 address
(config-if)#interface po1.12	Create po1 subinterface.
(config-if)# encapsulation dot1q 12	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac
(config-if)# ip address 150.12.1.1/24	Assign ipv4 address
(config-if)#interface po1.13	Create po1 subinterface.
(config-if)# encapsulation dot1q 13	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac
(config-if)# ip address 150.13.1.1/24	Assign ipv4 address
(config-if)#interface po1.14	Create po1 subinterface.
(config-if)# encapsulation dot1q 14	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac
(config-if)# ip address 150.14.1.1/24	Assign ipv4 address
(config-if)#interface po1.15	Create po1 subinterface.
(config-if)# encapsulation dot1q 15	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac
(config-if)# ip address 150.15.1.1/24	Assign ipv4 address
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
PE2 Configuration:	
Loopback Interface:	
#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 2.2.2.2/32 secondary	Configure IP address on loopback interface.
(config-if)# prefix-sid index 2	Configuring prefix sid for segment id
(config-if)#commit	Commit the transaction.
(config-if)#exit	Exit interface mode

Global EVPN MPLS Command:

#configure terminal	Enter configuration mode.
(config)#load-balance enable	Enable Load balance
(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware profile for evpn mpls multihoming
(config)#evpn mpls enable	Enable EVPN MPLS
(config)#evpn mpls irb	Enable EVPN MPLS IRB
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming
(config)#evpn mpls vtep-ip-global 2.2.2.2	Configuring VTEP global IP to loopback IP
(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.4466	Configure Anycast gateway mac for MH. This command is mandatory for MH nodes.
(config)#commit	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature.

Configure SR:

(config)#segment-routing	Configure segment routing
(config-sr)# mpls sr-prefer	Set mpls prefer segment routing over other protocols
(config-sr)#exit	Exit from router sr mode
(config)#commit	Commit the transaction.

Configure LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)# transport-address ipv4 2.2.2.2	Configuring transport address
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

MLAG Configuration:

(config)#interface mlag1	Create mlag interface
(config-if)# switchport	Configuring as L2 port
(config-if)# load-interval 30	Configure load interval
(config-if)# exit	Exit from interface mode
(config)#interface po1	Configure dynamic lag
(config-if)# switchport	Configuring as L2 port
(config-if)# mtu 1500	Set mtu value
(config-if)# mlag 1	Attach mlag
(config-if)#interface xe9	Enter interface mode
(config-if)# speed 10g	Set speed as 10g
(config-if)# channel-group 1 mode active	Attach the channel group po1

(config-if)# exit	Exit from interface mode
(config)#mcec domain configuration	Create mcec domain
(config-mcec-domain)# domain-address 1111.2222.3333	Configure mcec domain address
(config-mcec-domain)# domain-system-number 2	Configure system number
(config-mcec-domain)# intra-domain-link xe4	Configure ideal interface between mlag devices
(config-mcec-domain)# domain-hello-timeout long	Configure domain hello timeout
(config)#commit	Commit the transaction.

Interface Configuration Network Side:

(config-if)#interface xe6	Enter the Interface mode for xe6.
(config-if)# ip address 30.1.1.1/24	Configure ipv4 address
(config-if)# mtu 1522	Configure mtu
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf as p2p
(config-if)# enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#interface xe26	Enter the Interface mode for xe26.
(config-if)# ip address 40.1.1.1/24	Configure ipv4 address
(config-if)# mtu 2000	Configure mtu
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# mpls ldp-igp sync ospf	Configure ldp sync with ospf
(config-if)# ip ospf network point-to-point	Configure ospf as p2p
(config-if)# enable-ldp ipv4	Enable LDP on the physical interface
(config-router)#exit	Exit interface mode
(config)#commit	Commit the transaction.

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# network 1.1.1.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 20.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# ospf segment-routing global block 16000 23000	Configure SR global block for ospf
(config-router)# segment-routing mpls	Enable ospf SR
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

BGP Configuration:

(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 5.5.5.5 remote-as 100	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 fall-over bfd multihop	Configure BFD
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Enter in to address family ipv4 unicast mode
(config-router-af)# neighbor 5.5.5.5 activate	Activate PE3 neighbor
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family l2vpn evpn	Enter in to address family l2vpn vpn
(config-router-af)# neighbor 5.5.5.5 activate	Activate PE3 neighbor
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 unicast	Enter in to address family ipv6 unicast mode
(config-router-af)# neighbor 5.5.5.5 activate	Activate PE3 neighbor
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv4 vrf vrf102	Enter in to address family ipv4 vrf vrf102
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv4 vrf vrf101	Enter in to address family ipv4 vrf vrf102
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 vrf vrf101	Enter in to address family ipv6 vrf vrf101
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 vrf vrf102	Enter in to address family ipv6 vrf vrf102
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family
(config)#commit	Commit the transaction.

IP VRF Configuration:

(config-vrf)#ip vrf vrf102	Enter VRF mode
(config-vrf)# rd 10001:102	Configuring Route-Distinguisher value
(config-vrf)# route-target both 1.1.1.1:102	Configure RT
(config-vrf)# l3vni 102	Configure L3VNI to send ipv4 route through evpn

(config-vrf)#ip vrf vrf101	Create ip vrf vrf101
(config-vrf)# rd 10001:1	Configuring Route-Distinguisher value
(config-vrf)# route-target both 1.1.1.1:1	Configure RT
(config-vrf)# l3vni 101	Configure L3VNI to send ipv4 route through evpn
(config)#commit	Commit the transaction.

L3 VRF Port Configuration:

(config-if)#interface po1.11	Create po1 subinterface. We need to unconfigure mlag under po1 before creating subinterface.
(config-if)# encapsulation dot1q 11	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac for multi-homing
(config-if)# ip address 150.11.1.1/24	Assign ipv4 address
(config-if)#interface po1.12	Create po1 subinterface.
(config-if)# encapsulation dot1q 12	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac for multi-homing
(config-if)# ip address 150.12.1.1/24	Assign ipv4 address
(config-if)#interface po1.13	Create po1 subinterface.
(config-if)# encapsulation dot1q 13	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac for multi-homing
(config-if)# ip address 150.13.1.1/24	Assign ipv4 address
(config-if)#interface po1.14	Create po1 subinterface.
(config-if)# encapsulation dot1q 14	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 150.14.1.1/24	Assign ipv4 address
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac for multi-homing
(config-if)#interface po1.15	Create po1 subinterface.
(config-if)# encapsulation dot1q 15	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 150.15.1.1/24	Assign ipv4 address
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac for multi-homing
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

P1:

(config)#segment-routing	Configure SR.
(config-sr)# mpls sr-prefer	Prefer SR over other protocol.
(config-sr)#exit	Exit sr mode.
(config)#router ldp	Configure router ldp
(config-router)# transport-address ipv4 3.3.3.3	Configure transport address.
(config-router)#exit	Exit
(config)#interface po2	Configure dynamic LAG po2
(config-if)# ip address 10.1.1.2/24	Configure ipv4 address
(config-if)# mtu 2000	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface ce1	Configure network interface ce1
(config-if)# ip address 60.1.1.1/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface lo	Configure loopback interface
(config-if)# ip address 3.3.3.3/32 secondary	Configure secondary ip
(config-if)# prefix-sid absolute 16003	Configure SR segment id
(config-if)#interface xe10	Configure network interface xe10
(config-if)# speed 10g	Set speed 10g
(config-if)# ip address 30.1.1.2/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface xe14	Configure network interface xe14
(config-if)# ip address 50.1.1.1/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp

(config-if)#interface xe16	Enter interface mode
(config-if)# channel-group 2 mode active	Map dynamic lag po2
(config-if)#interface xe17	Enter interface mode
(config-if)# channel-group 2 mode active	Map dynamic lag po2
(config-if)# exit	Exit
(config)#router ospf 1	Configure router ospf 1
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Add loopback ip to ospf
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# network 30.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# network 50.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# network 60.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# segment-routing mpls	Enable SR ospf

P2:

(config)#segment-routing	Configure SR.
(config-sr)# mpls sr-prefer	Prefer SR over other protocol.
(config)#exit	Exit sr mode.
(config-sr)#router ldp	Configure router ldp
(config-router)# transport-address ipv4 4.4.4.4	Configure transport address.
(config-router)#exit	Exit
(config)#interface ce1	Configure network interface ce1
(config-if)# ip address 20.1.1.2/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface lo	Configure loopback interface
(config-if)# ip address 4.4.4.4/32 secondary	Configure secondary ip
(config-if)# prefix-sid absolute 16004	Configure SR segment id
(config-if)#interface xe14	Configure network interface xe14
(config-if)# ip address 50.1.1.2/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync

(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface xe20	Configure network interface xe20
(config-if)# ip address 70.1.1.1/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface xe26	Configure network interface xe26
(config-if)# ip address 40.1.1.2/24	Configure ipv4 address
(config-if)# mtu 2000	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#router ospf 1	Configure router ospf 1
(config-router)# network 4.4.4.4/32 area 0.0.0.0	Add loopback ip to ospf
(config-router)# network 20.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# network 40.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# network 50.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# network 70.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# segment-routing mpls	Enable SR ospf

PE3

Loopback Interface:	
#configure terminal	Enter configuration mode.
(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 5.5.5.5/32 secondary	Configure IP address on loopback interface.
(config-if)# prefix-sid absolute 16005	Configure SR segment id
(config)#commit	Commit the transaction.

Global EVPN MPLS Command:

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#evpn mpls irb	Enable EVPN MPLS IRB

(config)#commit	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature
(config)#evpn mpls vtep-ip-global 5.5.5.5	Configuring VTEP global IP to loopback IP
(config-evpn-mpls)#commit	Commit the transaction.

IP VRF Configuration:

(config-vrf)#ip vrf vrf102	Enter VRF mode
(config-vrf)# rd 10001:102	Configuring Route-Distinguisher value
(config-vrf)# route-target both 1.1.1.1:102	Configure RT value
(config-vrf)# l3vni 102	Configure L3VNI to send ipv4 route through evpn
(config-vrf)#ip vrf vrf101	Create ip vrf vrf101
(config-vrf)# rd 10002:1	Configuring Route-Distinguisher value
(config-vrf)# route-target both 1.1.1.1:1	Configure RT value
(config-vrf)# l3vni 101	Configure L3VNI to send ipv4 route through evpn
(config)#commit	Commit the transaction.

Configure SR:

(config)#segment-routing	Configure SR
(config-sr)# mpls sr-prefer	Prefer SR over other protocols for mpls
(config)#commit	Commit the transaction.
Global LDP:	
(config)#router ldp	Enter the Router LDP mode.
(config-router)# transport-address ipv4 5.5.5.5	Configure transport address
(config-router)#exit	Exit
(config)#commit	Commit the transaction.

Interface Configuration Network Side:

(config-if)#interface ce3	Configure network interface ce3
(config-if)# ip address 60.1.1.2/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface xe20	Enter the Interface mode for xe20.
(config-if)# ip address 70.1.1.2/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching

(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config)#commit	Commit the transaction.

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# network 5.5.5.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 60.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 70.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# segment-routing mpls	Enable SR ospf
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

BGP Configuration:

(config-router)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 1.1.1.1 remote-as 100	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 1.1.1.1 fall-over bfd multihop	Configure BFD
(config-router)# neighbor 2.2.2.2 remote-as 100	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 fall-over bfd multihop	Configure BFD
(config-router)# neighbor 1.1.1.1 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Enter ipv4 unicast address family
(config-router-af)# neighbor 1.1.1.1 activate	Activate neighbor PE1
(config-router-af)# neighbor 2.2.2.2 activate	Activate neighbor PE2
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family l2vpn evpn	Enter evpn address family
(config-router-af)# neighbor 1.1.1.1 activate	Activate neighbor PE1
(config-router-af)# neighbor 2.2.2.2 activate	Activate neighbor PE2
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 unicast	Enter ipv6 unicast address family
(config-router-af)# neighbor 1.1.1.1 activate	Activate neighbor PE1

(config-router-af)# neighbor 2.2.2.2 activate	Activate neighbor PE2
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv4 vrf vrf102	Enter vrf vrf102 address family
(config-router-af)# redistribute connected	Redistribute vrf connected routes to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 vrf vrf102	Enter ipv6 vrf vrf102 address family
(config-router-af)# redistribute connected	Redistribute vrf connected routes to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv4 vrf vrf101	Enter vrf vrf102 address family
(config-router-af)# redistribute connected	Redistribute vrf connected routes to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 vrf vrf101	Enter ipv6 vrf vrf101 address family
(config-router-af)# redistribute connected	Redistribute vrf connected routes to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)#exit	Exit bgp mode
(config)#commit	Commit the transaction.

L3 VRF Port Configuration:

(config-if)#interface xe13	Enter the Interface mode for xe3. This is for untagged traffic
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 201.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 2001::1/64	Assign ipv6 address
(config-if)#interface xe13.1	Create subinterface xe13.1
(config-if)# encapsulation dot1q 10	Configure encapsulation single tagged
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 210.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 2100::1/64	Assign ipv6 address
(config-if)#interface xe13.2	Create subinterface xe13.2
(config-if)# encapsulation dot1q 11 inner-dot1q 11	Configure encapsulation double tagged
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 220.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 2200::1/64	Assign ipv6 address
(config)#commit	Commit the transaction.

Validation

PE1

```
7030-PE1#sh mlag domain summary
```

```
-----  
Domain Configuration  
-----
```

```
Domain System Number      : 1  
Domain Address            : 1111.2222.3333  
Domain Priority           : 32768  
Intra Domain Interface    : xe4  
Domain Adjacency         : UP  
Domain Sync via          : Intra-domain-interface  
-----
```

```
MLAG Configuration  
-----
```

```
MLAG-1
```

```
  Mapped Aggregator        : po1  
  Physical properties Digest : a2 58 27 76 9f 45 ff 6c 2a 62 65 aa b6 22 8f 81  
  Total Bandwidth          : 0  
  Mlag Sync                : IN_SYNC  
  Mode                    : Active-Standby  
  Current Mlag state       : Active  
  Switchover-mode         : Revertive
```

```
7030-PE1#
```

```
Note:
```

```
PE1#sh etherchannel summary
```

```
  Aggregator po1 100001  
  Aggregator Type: Layer2  
  Admin Key: 16385 - Oper Key 16385  
    Link: xe10 (5011) sync: 1 (Mlag-Active-link)  
-----
```

```
  Aggregator po2 100002  
  Aggregator Type: Layer3  
  Admin Key: 0002 - Oper Key 0002  
    Link: xe18 (10025) sync: 1  
    Link: xe19 (10026) sync: 1
```

```
PE1#sh evpn mpls tunnel
```

```
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	evpn-id
1.1.1.1	5.5.5.5	Installed	02:22:38	02:22:38	102

```
Total number of entries are 1
```

```
PE1#sh ip bgp vrf all
```

```
BGP table version is 1, local router ID is 120.1.1.1
```

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
BGP Route Table for VRF vrf101					
*>i 45.1.1.0/24	5.5.5.5	0	100	0	?
*>i 52.1.1.0/24	5.5.5.5	0	100	0	?
*> 100.1.1.0/24	0.0.0.0	0	100	32768	?
*>i 101.101.101.2/32	5.5.5.5	0	100	0	?
*> 101.101.101.101/32	0.0.0.0	0	100	32768	?
*> 110.1.1.0/24	0.0.0.0	0	100	32768	?
*> 111.1.1.0/24	0.0.0.0	0	100	32768	?
*	0.0.0.0	1	100	32768	?
*> 120.1.1.0/24	0.0.0.0	0	100	32768	?
*>i 201.1.1.0	5.5.5.5	0	100	0	?
*>i 210.1.1.0	5.5.5.5	0	100	0	?
*>i 220.1.1.0	5.5.5.5	0	100	0	?

Total number of prefixes 11

BGP Route Table for VRF vrf102					
*>i 45.1.1.0/24	5.5.5.5	0	100	0	?
*> 51.1.1.0/24	0.0.0.0	0	100	32768	?
*>i 52.1.1.0/24	5.5.5.5	0	100	0	?
*>i 101.101.101.2/32	5.5.5.5	0	100	0	?
*>i 201.1.1.0	5.5.5.5	0	100	0	?
*>i 210.1.1.0	5.5.5.5	0	100	0	?
*>i 220.1.1.0	5.5.5.5	0	100	0	?

Total number of prefixes 7

*>i 5.5.5.5/32	5.5.5.5	0	100	0	i
----------------	---------	---	-----	---	---

Total number of prefixes 1

PE1#sh bgp l2vpn evpn prefix-route

RD[10002:1]

ESI	Eth-Tag	Prefix-Length	IP-Address	GW-IPAddress	L3VNID/LABEL	Nexthop	Encap
Router-Mac							
0	0	24	201.1.1.0	0.0.0.0	17	5.5.5.5	MPLS
0000:0000:0000							
0	0	24	210.1.1.0	0.0.0.0	17	5.5.5.5	MPLS
0000:0000:0000							
0	0	24	220.1.1.0	0.0.0.0	17	5.5.5.5	MPLS
0000:0000:0000							
0	0	64	2001::	::	17	5.5.5.5	MPLS
0000:0000:0000							
0	0	64	2100::	::	17	5.5.5.5	MPLS
0000:0000:0000							


```

0      0      64      2200::      ::      17      5.5.5.5 MPLS
0000:0000:0000

```

```

PE1#sh mpls ilm-table

```

```

Codes: > - installed ILM, * - selected ILM, p - stale ILM
      K - CLI ILM, T - MPLS-TP, s - Stitched ILM
      S - SNMP, L - LDP, R - RSVP, C - CRLDP
      B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
      O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
      P - SR Policy, U - unknown

```

```

LDP ilm-ecmp - disabled

```

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
NextHop		pri	LSP-Type			
O>	5.5.5.5/32	7	16005	16005	N/A	po2
10.1.1.2		Yes	LSP_DEFAULT			
O>	3.3.3.3/32	5	16003	3	N/A	po2
10.1.1.2		Yes	LSP_DEFAULT			
B>	vrf101	2	17	Nolabel	N/A	vrf101
A		Yes	LSP_DEFAULT			N/
B>	vrf102	1	16	Nolabel	N/A	vrf102
A		Yes	LSP_DEFAULT			N/
O>	4.4.4.4/32	6	16004	3	N/A	ce0
20.1.1.2		Yes	LSP_DEFAULT			
L>	4.4.4.4/32	10	35202	3	N/A	ce0
20.1.1.2		Yes	LSP_DEFAULT			
L>	3.3.3.3/32	8	35200	3	N/A	po2
10.1.1.2		Yes	LSP_DEFAULT			
L>	60.1.1.0/24	9	35201	3	N/A	po2
10.1.1.2		Yes	LSP_DEFAULT			
O>	20.1.1.2/32	3	35840	3	N/A	ce0
20.1.1.2		Yes	LSP_DEFAULT			
L>	70.1.1.0/24	12	35204	3	N/A	ce0
20.1.1.2		Yes	LSP_DEFAULT			
O>	10.1.1.2/32	4	35841	3	N/A	po2
10.1.1.2		Yes	LSP_DEFAULT			

```

PE1#sh mpls forwarding-table

```

```

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
      B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
      L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
      U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
      (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	NextHop					
O>	3.3.3.3/32	1	5	0	Yes	LSP_DEFAULT	3
po2	No	10.1.1.2					
L	3.3.3.3/32	9	4	-	Yes	LSP_DEFAULT	3
po2	No	10.1.1.2					
O>	4.4.4.4/32	2	6	0	Yes	LSP_DEFAULT	3
ce0	No	20.1.1.2					
L	4.4.4.4/32	4	3	-	Yes	LSP_DEFAULT	3
ce0	No	20.1.1.2					
O>	5.5.5.5/32	3	8	0	Yes	LSP_DEFAULT	16005
po2	No	10.1.1.2					

```

L      5.5.5.5/32      5      13      -      Yes      LSP_DEFAULT      34567
po2      No      10.1.1.2
ce0      No      20.1.1.2      14      -      Yes      LSP_DEFAULT      34566
L>      50.1.1.0/24      7      15(e)
po2      No      10.1.1.2      4      -      Yes      LSP_DEFAULT      3
ce0      No      20.1.1.2      3      -      Yes      LSP_DEFAULT      3
L>      60.1.1.0/24      10      16
po2      No      10.1.1.2      4      -      Yes      LSP_DEFAULT      3
L>      70.1.1.0/24      8      10
ce0      No      20.1.1.2      3      -      Yes      LSP_DEFAULT      3
PE1#

```

PE2

```
PE2#show mlag domain summary
```

```
-----
Domain Configuration
-----
```

```

Domain System Number      : 2
Domain Address             : 1111.2222.3333
Domain Priority            : 32768
Intra Domain Interface    : xe4
Domain Adjacency          : UP
Domain Sync via           : Intra-domain-interface
-----

```

```
MLAG Configuration
-----
```

```
MLAG-1
```

```

Mapped Aggregator          : po1
Physical properties Digest  : a2 58 27 76 9f 45 ff 6c 2a 62 65 aa b6 22 8f 81
Total Bandwidth            : 0
Mlag Sync                  : IN_SYNC
Mode                       : Active-Standby
Current Mlag state         : Standby
Switchover-mode            : Revertive

```

```
PE2#show evpn mpls tunnel
```

```
EVPN-MPLS Network tunnel Entries
```

Source	Destination	Status	Up/Down	Update	evpn-id
2.2.2.2	5.5.5.5	Installed	1d02h23m	1d02h23m	101

Total number of entries are 1

PE2#show evpn mpls tunnel label

EVPN-MPLS Network tunnel labels

(*) in Policy - tunnel-policy inherited from mac-vrf

				Local		Remote	
MPLS-Multipath		Underlay					
Destination	Status	VPN-ID	Policy	MC-Label	UC-Label	MC-Label	UC-
Label Grp-Name	NHLFE-ix	NW-Intf	NW-Label				
5.5.5.5	Installed	101	--	--	17	--	--
--	--	--	--				

Total number of entries are 1

PE2#show bgp l2vpn evpn prefix-route

RD[10002:1]

ESI	Eth-Tag	Prefix-Length	IP-Address	GW-IPAddress	L3VNID/LABEL	Nexthop
Encap	Router-Mac					
0	0	24	45.1.1.0	0.0.0.0	17	5.5.5.5
MPLS	0000:0000:0000					
0	0	24	52.1.1.0	0.0.0.0	17	5.5.5.5
MPLS	0000:0000:0000					
0	0	24	201.1.1.0	0.0.0.0	17	5.5.5.5
MPLS	0000:0000:0000					
0	0	24	210.1.1.0	0.0.0.0	17	5.5.5.5
MPLS	0000:0000:0000					
0	0	24	220.1.1.0	0.0.0.0	17	5.5.5.5
MPLS	0000:0000:0000					
0	0	32	101.101.101.2	0.0.0.0	17	5.5.5.5
MPLS	0000:0000:0000					
0	0	64	2001::	::	17	5.5.5.5
MPLS	0000:0000:0000					
0	0	64	2100::	::	17	5.5.5.5
MPLS	0000:0000:0000					
0	0	64	2200::	::	17	5.5.5.5
MPLS	0000:0000:0000					

PE2#show ip bgp vrf all

BGP table version is 1, local router ID is 0.0.0.0

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
BGP Route Table for VRF vrf101					
*>i 201.1.1.0	5.5.5.5	0	100	0	?
*>i 210.1.1.0	5.5.5.5	0	100	0	?
*>i 220.1.1.0	5.5.5.5	0	100	0	?

Total number of prefixes 6

```
*>i 5.5.5.5/32          5.5.5.5          0          100          0          i
```

Total number of prefixes 1

PE2#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM

K - CLI ILM, T - MPLS-TP, s - Stitched ILM

S - SNMP, L - LDP, R - RSVP, C - CRLDP

B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT

O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI

P - SR Policy, U - unknown

LDP ilm-ecmp - disabled

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nexthop		pri	LSP-Type			
O>	5.5.5.5/32	8	16005	16005	N/A	xe6
30.1.1.2		Yes	LSP_DEFAULT			
O>	1.1.1.1/32	5	16001	16001	N/A	xe6
30.1.1.2		Yes	LSP_DEFAULT			
B>	vrf101	2	17	Nolabel	N/A	vrf101 N/
A		Yes	LSP_DEFAULT			
B>	vrf102	1	16	Nolabel	N/A	vrf102 N/
A		Yes	LSP_DEFAULT			
O>	4.4.4.4/32	7	16004	3	N/A	xe26
40.1.1.2		Yes	LSP_DEFAULT			
O>	3.3.3.3/32	6	16003	3	N/A	xe6
30.1.1.2		Yes	LSP_DEFAULT			
L>	10.1.1.0/24	13	35204	3	N/A	xe6
30.1.1.2		Yes	LSP_DEFAULT			
L>	20.1.1.0/24	10	35201	3	N/A	xe26
40.1.1.2		Yes	LSP_DEFAULT			
L>	4.4.4.4/32	9	35200	3	N/A	xe26
40.1.1.2		Yes	LSP_DEFAULT			
L>	3.3.3.3/32	12	35203	3	N/A	xe6
30.1.1.2		Yes	LSP_DEFAULT			
L>	70.1.1.0/24	11	35202	3	N/A	xe26
40.1.1.2		Yes	LSP_DEFAULT			
O>	30.1.1.2/32	3	35840	3	N/A	xe6
30.1.1.2		Yes	LSP_DEFAULT			
L>	60.1.1.0/24	14	35205	3	N/A	xe6
30.1.1.2		Yes	LSP_DEFAULT			
O>	40.1.1.2/32	4	35841	3	N/A	xe26
40.1.1.2		Yes	LSP_DEFAULT			

PE2#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

(m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
O>	1.1.1.1/32	1	6	0	Yes	LSP_DEFAULT	16001
xe6	No	30.1.1.2					

```

L      1.1.1.1/32      5      16      -      Yes      LSP_DEFAULT      34573
xe26      No      40.1.1.2
      17      -      Yes      LSP_DEFAULT      34573
xe6      No      30.1.1.2
O>      3.3.3.3/32      2      7      0      Yes      LSP_DEFAULT      3
xe6      No      30.1.1.2
L      3.3.3.3/32      6      3      -      Yes      LSP_DEFAULT      3
xe6      No      30.1.1.2
O>      4.4.4.4/32      3      8      0      Yes      LSP_DEFAULT      3
xe26      No      40.1.1.2
L      4.4.4.4/32      11      4      -      Yes      LSP_DEFAULT      3
xe26      No      40.1.1.2
O>      5.5.5.5/32      4      10      0      Yes      LSP_DEFAULT      16005
xe6      No      30.1.1.2
L      5.5.5.5/32      7      19      -      Yes      LSP_DEFAULT      34575
xe26      No      40.1.1.2
      20      -      Yes      LSP_DEFAULT      34575
xe6      No      30.1.1.2
L>      10.1.1.0/24      8      14
      3      -      Yes      LSP_DEFAULT      3
xe6      No      30.1.1.2
L>      20.1.1.0/24      12      21
      4      -      Yes      LSP_DEFAULT      3
xe26      No      40.1.1.2
L>      50.1.1.0/24      9      22 (e)
      4      -      Yes      LSP_DEFAULT      3
xe26      No      40.1.1.2
      3      -      Yes      LSP_DEFAULT      3
xe6      No      30.1.1.2
L>      60.1.1.0/24      10      14
      3      -      Yes      LSP_DEFAULT      3
xe6      No      30.1.1.2
L>      70.1.1.0/24      13      21
      4      -      Yes      LSP_DEFAULT      3
xe26      No      40.1.1.2
PE2#

```

PE3:

PE3#show evpn mpls tunnel

EVPN-MPLS Network tunnel Entries

Source	Destination	Status	Up/Down	Update	evpn-id
5.5.5.5	1.1.1.1	Installed	2d05h17m	2d05h17m	102
5.5.5.5	1.1.1.1	Installed	2d05h17m	2d05h17m	101

Total number of entries are 2

PE3#show ip bgp vrf all

BGP table version is 1, local router ID is 220.1.1.1

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,

l - labeled, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
BGP Route Table for VRF vrf101					
*> 45.1.1.0/24	210.1.1.2	0	100	32768	?
*>i 51.1.1.0/24	1.1.1.1	0	100	0	?
*> 52.1.1.0/24	0.0.0.0	0	100	32768	?
*>i 100.1.1.0/24	1.1.1.1	0	100	0	?
*> 101.101.101.2/32	0.0.0.0	0	100	32768	?
*>i 101.101.101.101/32	1.1.1.1	0	100	0	?
*>i 110.1.1.0/24	1.1.1.1	0	100	0	?
*>i 111.1.1.0/24	1.1.1.1	0	100	0	?
*>i 120.1.1.0/24	1.1.1.1	0	100	0	?
*> 201.1.1.0	0.0.0.0	0	100	32768	?
*> 210.1.1.0	0.0.0.0	0	100	32768	?
*> 220.1.1.0	0.0.0.0	0	100	32768	?

Total number of prefixes 12

...skipping 1 line

BGP Route Table for VRF vrf102

*>i 51.1.1.0/24	1.1.1.1	0	100	0	?
-----------------	---------	---	-----	---	---

Total number of prefixes 1

*> 5.5.5.5/32	0.0.0.0	0	100	32768	i
---------------	---------	---	-----	-------	---

Total number of prefixes 1

PE3#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM

K - CLI ILM, T - MPLS-TP, s - Stitched ILM

S - SNMP, L - LDP, R - RSVP, C - CRLDP

B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT

O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI

P - SR Policy, U - unknown

LDP ilm-ecmp - disabled

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nextthop	pri	LSP-Type				
O> 4.4.4.4/32		6	16004	3	N/A	xe20
70.1.1.1	Yes	LSP_DEFAULT				
B> vrf101		2	17	Nolabel	N/A	vrf101
A	Yes	LSP_DEFAULT				N/
B> vrf102		1	16	Nolabel	N/A	vrf102
A	Yes	LSP_DEFAULT				N/
O> 3.3.3.3/32		5	16003	3	N/A	ce3
60.1.1.1	Yes	LSP_DEFAULT				
O> 1.1.1.1/32		12	16001	16001	N/A	ce3
60.1.1.1	Yes	LSP_DEFAULT				
L> 20.1.1.0/24		10	35203	3	N/A	xe20
70.1.1.1	Yes	LSP_DEFAULT				

```

L> 4.4.4.4/32      8      35201      3      N/A      xe20
70.1.1.1      Yes      LSP_DEFAULT
L> 3.3.3.3/32      7      35200      3      N/A      ce3
60.1.1.1      Yes      LSP_DEFAULT
L> 40.1.1.0/24     9      35202      3      N/A      xe20
70.1.1.1      Yes      LSP_DEFAULT
O> 70.1.1.1/32     4      35840      3      N/A      xe20
70.1.1.1      Yes      LSP_DEFAULT
L> 10.1.1.0/24     11     35204      3      N/A      ce3
60.1.1.1      Yes      LSP_DEFAULT
O> 60.1.1.1/32     3      35841      3      N/A      ce3
60.1.1.1      Yes      LSP_DEFAULT

```

PE3#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
 (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
O>	1.1.1.1/32	9	13	0	Yes	LSP_DEFAULT	16001
ce3	No	60.1.1.1					
L	1.1.1.1/32	10	14	-	Yes	LSP_DEFAULT	34566
ce3	No	60.1.1.1					
			16	-	Yes	LSP_DEFAULT	34564
xe20	No	70.1.1.1					
O>	3.3.3.3/32	1	6	0	Yes	LSP_DEFAULT	3
ce3	No	60.1.1.1					
L	3.3.3.3/32	3	3	-	Yes	LSP_DEFAULT	3
ce3	No	60.1.1.1					
O>	4.4.4.4/32	2	7	0	Yes	LSP_DEFAULT	3
xe20	No	70.1.1.1					
L	4.4.4.4/32	5	4	-	Yes	LSP_DEFAULT	3
xe20	No	70.1.1.1					
L>	10.1.1.0/24	8	8				
			3	-	Yes	LSP_DEFAULT	3
ce3	No	60.1.1.1					
L>	20.1.1.0/24	7	10				
			4	-	Yes	LSP_DEFAULT	3
xe20	No	70.1.1.1					
L>	40.1.1.0/24	6	10				
			4	-	Yes	LSP_DEFAULT	3
xe20	No	70.1.1.1					
L>	50.1.1.0/24	4	11 (e)				
			4	-	Yes	LSP_DEFAULT	3
xe20	No	70.1.1.1					
			3	-	Yes	LSP_DEFAULT	3
ce3	No	60.1.1.1					

PE3

PE3#show bgp l2vpn evpn prefix-route

RD[10001:1]

ESI		Eth-Tag	Prefix-Length	IP-Address	GW-IPAddress	L3VNID/LABEL
Nexthop	Encap	Router-Mac				
0		0	24	100.1.1.0	0.0.0.0	17
1.1.1.1	MPLS	0000:0000:0000				
0		0	24	110.1.1.0	0.0.0.0	17
1.1.1.1	MPLS	0000:0000:0000				
0		0	24	111.1.1.0	0.0.0.0	17
1.1.1.1	MPLS	0000:0000:0000				
0		0	24	120.1.1.0	0.0.0.0	17
1.1.1.1	MPLS	0000:0000:0000				
0		0	64	1000::	::	17
1.1.1.1	MPLS	0000:0000:0000				
0		0	64	1100::	::	17
1.1.1.1	MPLS	0000:0000:0000				
0		0	64	1110::	::	17
1.1.1.1	MPLS	0000:0000:0000				
0		0	64	1200::	::	17
1.1.1.1	MPLS	0000:0000:0000				
RD[10001:102]						
ESI		Eth-Tag	Prefix-Length	IP-Address	GW-IPAddress	L3VNID/LABEL
Nexthop	Encap	Router-Mac				
0		0	24	51.1.1.0	0.0.0.0	16
1.1.1.1	MPLS	0000:0000:0000				
PE3#						

CHAPTER 2 L3VPN GR Configuration

Using BGP graceful restart, the data-forwarding plane of a router can continue to process and forward packets even if the control plane - which is responsible for determining best paths - fails. Graceful restart also reduces routing flaps, stabilizing the network and reducing control-plane resource consumption.

By exchanging a new BGP capability (BGP capability code 64) in the initial BGP open messages that establish the session, the restarting router and its peers show that they are aware of the BGP graceful restart mechanism when the initial BGP connection is established. In addition, the restarting router provides its peers with a list of supported address-families (VPNv4, IPv4, and IPV6) for which it can maintain a forwarding state across a BGP restart.

The peer router's TCP connection might be cleared, when the router's BGP process is restarted. Under normal circumstances, this would cause the peer router to clear all routes associated with the restarting router. But with a BGP graceful restart, this doesn't happen. Instead, in expectation of the restarting router shortly re-establishing the BGP session, the peer router marks all routes as "stale" yet continues to use them to forward packets. Likewise, the restarting router also continues forwarding packets in the interim.

When the restarting router opens the new BGP session, it will again send BGP capability 64 to its peers. But this time, flags will be set in the graceful restart capabilities exchange to let the peer router know that the BGP process has restarted.

The goal of the BGP graceful restart was to minimize the duration and reach of an outage associated with a failed BGP process. To do this, the software extensions must be deployed on both the router restarting the BGP process and the BGP peers of that router. The peers help the BGP process regain lost forwarding information and also help isolate failures from the rest of the network.

While forwarding packets, the peer router will refresh the restarting router with any relevant BGP routing information base (RIB) updates. The peer signals that it has finished sending the updates with an "End-of-RIB" (EOR) marker - an "empty" BGP update message. EOR markers help speed convergence because once the restarting router has received them from all peers, it can begin best-path selection again using the new routing information. Similarly, the restarting router then sends any updates to its peer routers and uses the EOR marker to indicate the completion of the process.

As part of this feature, we will be extending the feature for VPNv4 AF.

Topology

In the below example shows to configure BGP VPNv4 neighborhood between PE1 and PE2.

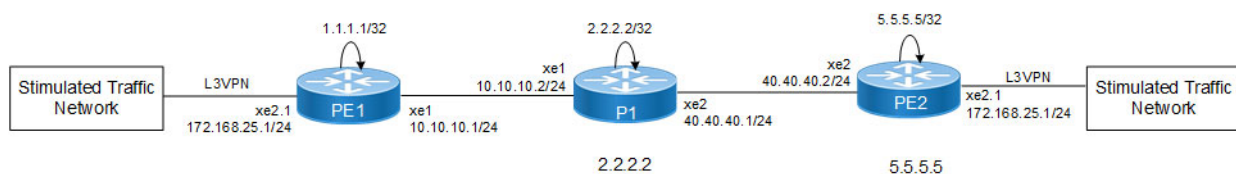


Figure 2-28: L3VPN GR Topology

L3VPN GR Configuration

Configuration

Below are the configurations and validations of L3VPN GR with OSPF as IGP. We can also configure ISIS as IGP and LDP/RSVP as transport.

PE1

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32
(config-if)#exit	Exit interface mode.
(config)#ip-vrf l3vpn	Configure IP VRF L3VPN.
(config-vrf)#rd 1:300	Enter RD value.
(config-vrf)#route-target both 300:400	Enter RT value.
(config-vrf)#exit	Exiting from VRF mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1.
(config-router)#targeted-peer ipv4 2.2.2.2	Configure targeted peer.
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit-targeted-peer-mode
(config-router)#targeted-peer ipv4 5.5.5.5	Configure targeted peer.
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.10.10.1/24	Configure IPv4 address for xe1.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe1.
(config-if)#exit	Exit interface mode
(config)#interface xe2.1	Configure access-port .
(config-if)#description MPLS-L3VPN	Giving Interface Description
(config-if)#encapsulation dot1q 4	Setting Encapsulation to dot1q with VLAN ID 4
(config-if)#load-interval 30	Load interval setting
(config-if)#ip vrf forwarding l3vpn	Bind the interface connected to the CE router with VRF l3vpn
(config-if)#ip address 172.168.25.2/24	Assign the IPv4 address.
(config)#router ospf 1	Configure the routing process and specify the Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
(config)#ospf router-id 1.1.1.1	Configure OSPF router-ID same as loopback interface IP address

(config-router) #network 1.1.1.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router) #network 10.10.10.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-if) #exit	Exit interface mode.
(config) #router bgp 100	Enter router BGP mode
(config-router) #bgp router-id 1.1.1.1	Configuring the BGP router id 1.1.1.1.
(config-router) #bgp graceful-restart restart-time 100	Enable BGP GR with restart timer 100.
(config-router) #neighbor 5.5.5.5 remote-as 100	Configure neighbor 5.5.5.5.
(config-router) #neighbor 5.5.5.5 update-source lo	Update source lo for neighbor 5.5.5.5.
(config-router) #address-family ipv4 unicast	Enter address-family IPv4 unicast.
(config-router-af) #redistribute connected	Redistribute connected.
(config-router) #neighbor 5.5.5.5 activate	Activate neighbor.
(config-router) #address-family vpnv4 unicast	Entering Address family VPNv4 unicast.
(config-router-af) #neighbor 5.5.5.5 activate	Activate the neighbor 5.5.5.5.
(config-router-af) #neighbor 5.5.5.5 capability graceful-restart	Activate capability graceful restart for neighbor 5.5.5.5.
(config-router-af) #exit-address-family	Exit address family.
(config-router) #address-family ipv4 vrf l3vpn	Entering address family.
(config-router-af) #redistribute connected	Redistribute connected.
(config-router) #neighbor 172.168.25.1 remote-as 600	Configure neighbor 172.168.25.1.
(config-router) #neighbor 172.168.25.1 activate	Activate neighbor.
(config-router-af) #commit	Commit all the transactions.

P1

#configure terminal	Enter configuration mode.
(config) #interface lo	Specify the loopback (lo) interface to be configured.
(config-if) #ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if) #exit	Exit interface mode.
(config) #router ldp	Enter router mode for LDP.
(config-router) #router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.
(config-router) #transport-address ipv4 2.2.2.2 0	Configure the transport address for IPV4 (for IPV6, use ipv6) to be used for a TCP session over which LDP will run.
Note:	It is preferable to use the loopback address as the transport address.
(config-router) #targeted-peer ipv4 1.1.1.1	Configure targeted peer.
(config-router-targeted-peer) #exit-targeted-peer-mode	Exit-targeted-peer-mode.
(config-router) #targeted-peer ipv4 5.5.5.5	Configure targeted peer.

(config-router-targeted-peer)#exit-targeted-peer-mode	Exit-targeted-peer-mode.
(config-router)#exit	Exit-targeted-peer-mode.
(config-if)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.10.10.2/24	Configure IPv4 address for xe1.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 40.40.40.1/24	Configure IPv4 address for xe2.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe2.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the routing process and specify the Process ID. The Process ID should be a unique positive integer identifying the routing process.
(config)#ospf router-id 2.2.2.2	Configure OSPF router-ID same as loopback interface IP address.
(config-router) #network 2.2.2.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router) #network 10.10.10.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 40.40.40.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with BFD.
(config-if)#exit	Exit interface mode.

PE-2

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 5.5.5.5/32 secondary	Set the IP address of the loopback interface to 5.5.5.5/32.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 5.5.5.5	Set the router ID to IP address 5.5.5.5.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit-targeted-peer-mode.
(config-router)#targeted-peer ipv4 2.2.2.2	Configure targeted peer.
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit-targeted-peer-mode.
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.

(config-if)#ip address 40.40.40.2/24	Configure IPv4 address for xe1.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe1.
(config-if)#exit	Exit interface mode.
(config-if)#exit	Exit interface mode.
(config)#interface xe2.1	Enter interface mode.
(config-if)#description MPLS-L3VPN	Giving Interface Description.
(config-if)#encapsulation dot1q 4	Setting Encapsulation to dot1q with VLAN ID 4.
(config-if)#load-interval 30	Load interval setting.
(config-if)#ip vrf forwarding l3vpn	Bind the interface connected to the CE router with VRF L3VPN.
(config-if)#ip address 172.168.25.2/24	Assign the IPv4 address.
(config)#router ospf 1	The Process ID should be a unique positive integer identifying the routing process.
(config)#ospf router-id 5.5.5.5	Configure OSPF router-ID same as loopback interface IP address.
(config-router) #network 5.5.5.5/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router) #network 40.40.40.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-if)#exit	Exit interface mode.
(config)#router bgp 100	Enter router BGP mode
(config-router)#bgp router-id 5.5.5.5	Configuring the bgp router id 1.1.1.1.
(config-router)#bgp graceful-restart restart-time 100	Enable BGP GR with restart timer 100.
(config-router)#neighbor 1.1.1.1 remote-as 100	Configure neighbor 1.1.1.1.
(config-router)#neighbor 1.1.1.1 update-source lo	Update source lo for neighbor 1.1.1.1.
(config-router)#address-family ipv4 unicast	Enter address-family ipv4 unicast.
(config-router-af)#redistribute connected	Redistribute connected.
(config-router)#neighbor 1.1.1.1 activate	Activate neighbor.
(config-router)#address-family vpnv4 unicast	Entering Address family VPNv4 unicast.
(config-router-af)#neighbor 1.1.1.1 activate	Activate the neighbor 1.1.1.1.
(config-router-af)#neighbor 1.1.1.1 capability graceful-restart	Activate capability graceful restart for neighbor 1.1.1.1.
(config-router-af)#exit-address-family	Exit address family.
(config-router)#address-family ipv4 vrf l3vpn	Entering address family.
(config-router-af)#redistribute connected	Redistribute connected.
(config-router)#neighbor 172.168.26.1 remote-as 700	Configure neighbor 172.168.26.1.
(config-router)#neighbor 172.168.26.1 activate	Activate neighbor.
(config-router-af)#commit	Commit all the transactions.

Validation

Restart BGP Gracefully

PE1:

```
PE1#restart bgp graceful
%Warning : BGP process will stop and needs to restart manually,
You may lose bgp configuration,if not saved
Proceed for graceful restart? (y/n):y
%% Managed module is down or crashed
```

R1#show mpls ilm-table

```
Codes: > - installed ILM, * - selected ILM, p - stale ILM
      K - CLI ILM, T - MPLS-TP, s - Stitched ILM
      S - SNMP, L - LDP, R - RSVP, C - CRLDP
      B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
      O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
      P - SR Policy, U - unknown
```

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nexthop		LSP-Type				
		LSP_DEFAULT				
B> p	77.77.80.0/24	7	24323	Nolabel	N/A	13vpn
N/A		LSP_DEFAULT				
B> p	77.77.78.0/24	5	24321	Nolabel	N/A	13vpn
N/A		LSP_DEFAULT				
B> p	77.77.77.0/24	4	24320	Nolabel	N/A	13vpn
N/A		LSP_DEFAULT				
B> p	77.77.79.0/24	6	24322	Nolabel	N/A	13vpn
N/A		LSP_DEFAULT				
B> p	77.77.81.0/24	8	24324	Nolabel	N/A	13vpn
N/A		LSP_DEFAULT				
B> p	172.168.25.0/24	9	24325	Nolabel	N/A	13vpn
N/A		LSP_DEFAULT				
V	12ckt:900	1	24960	Nolabel	po1	xe1
A		LSP_DEFAULT				N/

PE1#show mpls vrf-forwarding-table

```
Codes: > - installed FTN, * - selected FTN, p - stale FTN, B - BGP FTN
(m) - Service mapped over multipath transport
```

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-
Intf	Nexthop						
B> p	88.88.88.0/24	1	0	Yes	LSP_DEFAULT	24321	-
5.5.5.5							
B> p	88.88.89.0/24	2	0	Yes	LSP_DEFAULT	24321	-
5.5.5.5							
B> p	88.88.90.0/24	3	0	Yes	LSP_DEFAULT	24321	-
5.5.5.5							

```

B >p 88.88.91.0/24      4      0      Yes   LSP_DEFAULT  24321      -
5.5.5.5
B >p 88.88.92.0/24      5      0      Yes   LSP_DEFAULT  24321      -
5.5.5.5
B> p 172.168.26.0/24    6      0      Yes   LSP_DEFAULT  24321      -
5.5.5.5

```

```
PE1#show nsm forwarding-timer
```

```

Protocol-Name  GR-State  Time Remaining (sec)  Disconnected-time
BGP            ACTIVE      74                    2022/01/13 16:33:43

```

```
PE#show run bgp
```

```
!
```

```
PE1#show ip bgp vpnv4 all
```

PE2:

```
PE2#show ip bgp vpnv4 all
```

```

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal, l - labeled

```

```
S Stale
```

```
Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:300 (Default for VRF l3vpn)					
*>i 77.77.77.0/24	1.1.1.1	0	100	0	600 i
*>i 77.77.78.0/24	1.1.1.1	0	100	0	600 i
*>i 77.77.79.0/24	1.1.1.1	0	100	0	600 i
*>i 77.77.80.0/24	1.1.1.1	0	100	0	600 i
*>i 77.77.81.0/24	1.1.1.1	0	100	0	600 i
*> l 88.88.88.0/24	172.168.26.1	0	100	0	700 i
*> l 88.88.89.0/24	172.168.26.1	0	100	0	700 i
*> l 88.88.90.0/24	172.168.26.1	0	100	0	700 i
*> l 88.88.91.0/24	172.168.26.1	0	100	0	700 i
*> l 88.88.92.0/24	172.168.26.1	0	100	0	700 i
*>i 172.168.25.0/24	1.1.1.1	0	100	0	?
*> l 172.168.26.0/24	0.0.0.0	0	100	32768	?
Announced routes count = 6					
Accepted routes count = 6					
Route Distinguisher: 1:300					
S>i 77.77.77.0/24	1.1.1.1	0	100	0	600 i
S>i 77.77.78.0/24	1.1.1.1	0	100	0	600 i
S>i 77.77.79.0/24	1.1.1.1	0	100	0	600 i
S>i 77.77.80.0/24	1.1.1.1	0	100	0	600 i
S>i 77.77.81.0/24	1.1.1.1	0	100	0	600 i
S>i 172.168.25.0/24	1.1.1.1	0	100	0	?
Announced routes count = 0					

After Restarting the BGP Manually

PE1:

```
PE1#start-shell
bash-5.0$ su
Password:
root@PE1:/home/ocnos# cd /usr/local/sbin/
root@PE1:/usr/local/sbin# ./bgpd -d

PE1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
      K - CLI ILM, T - MPLS-TP, s - Stitched ILM
      S - SNMP, L - LDP, R - RSVP, C - CRLDP
      B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
      O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
      P - SR Policy, U - unknown
```

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nexthop		LSP-Type				
A	B> 77.77.80.0/24	7	24323	Nolabel	N/A	13vpn N/
A	B> 77.77.78.0/24	5	24321	Nolabel	N/A	13vpn N/
A	B> 77.77.77.0/24	4	24320	Nolabel	N/A	13vpn N/
A	B> 77.77.79.0/24	6	24322	Nolabel	N/A	13vpn N/
A	B> 77.77.81.0/24	8	24324	Nolabel	N/A	13vpn N/
A	B> 172.168.25.0/24	9	24325	Nolabel	N/A	13vpn N/
A	V 12ckt:900	1	24960	Nolabel	po1	xe1 N/

```
PE1#show mpls vrf-forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, B - BGP FTN
(m) - Service mapped over multipath transport
```

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-
Intf	Nexthop						
5.5.5.5	B>88.88.88.0/24	1	0	Yes	LSP_DEFAULT 24321	-	
5.5.5.5	B>88.88.89.0/24	2	0	Yes	LSP_DEFAULT 24321	-	
5.5.5.5	B>88.88.90.0/24	3	0	Yes	LSP_DEFAULT 24321	-	
5.5.5.5	B>88.88.91.0/24	4	0	Yes	LSP_DEFAULT 24321	-	
5.5.5.5	B>88.88.92.0/24	5	0	Yes	LSP_DEFAULT 24321	-	
5.5.5.5	B> 172.168.26.0/24	6	0	Yes	LSP_DEFAULT 24321	-	

PE2:

```
PE2#show ip bgp vpnv4 all
```

```
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal, l - labeled
```

```
S Stale
```

```
Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:300 (Default for VRF l3vpn)					
*>i 77.77.77.0/24	1.1.1.1	0	100	0 600	i
*>i 77.77.78.0/24	1.1.1.1	0	100	0 600	i
*>i 77.77.79.0/24	1.1.1.1	0	100	0 600	i
*>i 77.77.80.0/24	1.1.1.1	0	100	0 600	i
*>i 77.77.81.0/24	1.1.1.1	0	100	0 600	i
*> l 88.88.88.0/24	172.168.26.1	0	100	0 700	i
*> l 88.88.89.0/24	172.168.26.1	0	100	0 700	i
*> l 88.88.90.0/24	172.168.26.1	0	100	0 700	i
*> l 88.88.91.0/24	172.168.26.1	0	100	0 700	i
*> l 88.88.92.0/24	172.168.26.1	0	100	0 700	i
*>i 172.168.25.0/24	1.1.1.1	0	100	0 ?	
*> l 172.168.26.0/24	0.0.0.0	0	100	32768 ?	
Announced routes count = 6					
Accepted routes count = 6					
Route Distinguisher: 1:300					
>i 77.77.77.0/24	1.1.1.1	0	100	0 600	i
>i 77.77.78.0/24	1.1.1.1	0	100	0 600	i
>i 77.77.79.0/24	1.1.1.1	0	100	0 600	i
>i 77.77.80.0/24	1.1.1.1	0	100	0 600	i
>i 77.77.81.0/24	1.1.1.1	0	100	0 600	i
>i 172.168.25.0/24	1.1.1.1	0	100	0 ?	
Announced routes count = 0					

CHAPTER 3 TWAMP over L3VPN Configuration

This chapter contains a complete sample TWAMP over L3VPN configuration.

Two-way Active Measurement Protocol (TWAMP) is an open protocol for measuring network performance between any two devices. The TWAMP MPLS transport is implemented as part of supporting TWAMP on routers which acts as MPLS routers both in the roles of LERs as well as intermediate routers. OcNOS version 6.0.0 also supports the end to end statistics calculation when multiple paths are available between sender and reflector with multihop support.

The user can use the link delay metrics such as average, minimum, and maximum delay, and delay variance to determine the network latency. Using link delay metrics will enable troubleshooting latency issues or apply Traffic Engineering (TE) solutions to meet Service Level Agreements (SLAs).

The TWAMP protocol is designed to do such measurements, and a basic implementation of this protocol has already been implemented in OcNOS. This feature here is a TWAMP protocol in OcNOS where the focus will be on accuracy and configurable advertisement of the measured data.

L3VPN (based on MPLS) Supported scenarios:

In general, TWAMP over L3VPN works on:

CE-CE Overlay Only

CE-PE Overlay Only

PE-PE Both Under lay and over lay

Topology

Figure 3-29 displays a sample TWAMP over L3VPN topology.

- CE1 and CE2 are customer edge routers
- PE1 and PE2 are IPv4 Provider Edge routers
- P1 is the router at the core of the IPv4 MPLS provider network

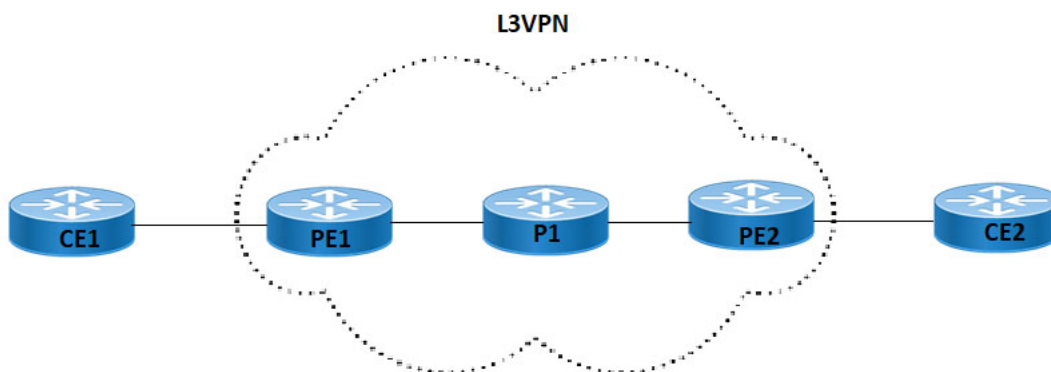


Figure 3-29: TWAMP over L3VPN Topology

Configure TWAMP over L3VPN for LDP

PE1

#configure terminal	Enter Configure mode.
(config)# ip vrf vrf100	Create a new VRF named vrf100
(config-vrf)#rd 100:1	Assign the route distinguisher (RD) value as 100:1
(config-vrf)#route-target both 100:1	Import routes between route target (RT) ext-communities 100 and 1
(config-vrf)#exit	Exit VRF mode
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 18.18.18.18/32 secondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#interface xe8	Enter Interface mode
(config-if)# ip address 10.1.1.18/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode
(config)#interface xe11	Enter Interface mode
(config-if)# ip vrf forwarding vrf100	Bind the interface connected to the CE1 router with VRF 100
(config-if)# ip address 100.1.1.1/24	Assign IP address to interface
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 18.18.18.18	Configure router id as loopback address
(config-router)#transport-address ipv4 18.18.18.18	Configure ldp transport address as loopback address
(config-router)#exit	Exit from the router ldp mode
(config)# router ospf 1	Enter Router OSPF mode
(config-router)# ospf router-id 18.18.18.18	Configure OSPF router-id
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# network 18.18.18.18/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# commit	Commit the configurations
(config-router)# exit	Exit from router OSPF mode
(config)# router bgp 100	Enter BGP router mode
(config-router)# bgp router-id 18.18.18.18	Configure BGP router-id
(config-router)# neighbor 8.8.8.8 remote-as 100	Configure PE2 as an iBGP4+ neighbor
(config-router)# neighbor 8.8.8.8 up-date-source lo	Update the source as loopback for iBGP peering with the remote PE2 router

(config-router)# address-family vpnv4 unicast	Enter address-family vpnv4 mode
(config-router-af)# neighbor 8.8.8.8 activate	Activate the PE2 neighbor in the vpnv4 address family
(config-router-af)# neighbor 8.8.8.8 next-hop-self	Activate the neighbor as next hop self
(config-router-af)#exit	Exit form address family
(config-router)# address-family ipv4 vrf vrf100	Enter the IPv4 address family for VRF 100
(config-router-af)# redistribute connected	Redistribute connected routes
(config-router-af)# neighbor 100.1.1.2 remote-as 200	Configure CE1 neighbor in the vrf address family
(config-router-af)# neighbor 100.1.1.2 activate	Activate the CE1 neighbor
(config-router-af)#exit	Exit form address family
(config-router)# commit	Commit the configurations

P1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 3.3.3.3	Configure router id as loopback address
(config-router)#transport-address ipv4 3.3.3.3	Configure ldp transport address as loopback address
(config-router)#exit	Exit from the router ldp mode
(config)#interface xe14	Enter Interface mode
(config-if)# ip address 10.1.1.3/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode
(config)#interface xe15	Enter Interface mode
(config-if)# ip address 11.1.1.3/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit interface mode
(config)# router ospf 1	Enter Router OSPF mode
(config-router)# ospf router-id 18.18.18.18	Configure OSPF router-id
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.

(config-router)# network 11.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# commit	Commit the configurations
(config-router)# exit	Exit from router OSPF mode

PE2

#configure terminal	Enter Configure mode.
(config)#ip vrf vrf100	Create a new VRF named vrf100
(config-vrf)#rd 101:1	Assign the route distinguisher (RD) value as 101:1
(config-vrf)#route-target both 100:1	Import routes between route target (RT) ext-communities 100 and 1
(config-vrf)#exit	Exit VRF mode
(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 8.8.8.8	Configure router id as loopback address
(config-router)#transport-address ipv4 8.8.8.8	Configure ldp transport address as loopback address
(config-router)#exit	Exit from the router ldp mode
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 8.8.8.8/32 secondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#interface xe24	Enter Interface mode
(config-if)# ip address 11.1.1.8/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode
(config)#interface xe25	Enter Interface mode
(config-if)# ip vrf forwarding vrf100	Bind the interface connected to the CE1 router with VRF 100
(config-if)# ip address 101.1.1.1/24	Assign IP address to interface
(config-if)#exit	Exit interface mode
(config)# router ospf 1	Enter Router OSPF mode
(config-router)# ospf router-id 8.8.8.8	Configure OSPF router-id
(config-router)# network 11.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# network 8.8.8.8/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit from router OSPF mode
(config)# router bgp 100	Enter BGP router mode
(config-router)# bgp router-id 8.8.8.8	Configure BGP router-id
(config-router)# neighbor 18.18.18.18 re- mote-as 100	Configure PE1 as an iBGP4+ neighbor
(config-router)# neighbor 18.18.18.18 up- date-source lo	Update the source as loopback for iBGP peering with the remote PE1 router

(config-router)# address-family vpnv4 unicast	Enter address-family vpnv4 mode
(config-router-af)# neighbor 18.18.18.18 activate	Activate the PE1 neighbor in the vpnv4 address family
(config-router-af)# neighbor 18.18.18.18 next-hop-self	Activate the neighbor as next hop self
(config-router-af)#exit	Exit form address family
(config-router)# address-family ipv4 vrf vrf100	Enter the IPv4 address family for VRF 100
(config-router-af)# redistribute connected	Redistribute connected routes
(config-router-af)# neighbor 101.1.1.2 remote-as 200	Configure CE2 neighbor in the vrf address family
(config-router-af)# neighbor 101.1.1.2 activate	Activate the CE2 neighbor
(config-router-af)#exit	Exit form address family
(config-router)# commit	Commit the configurations

CE1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 37.37.37.37/32 secondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#interface xe24	Enter Interface mode
(config-if)# ip address 100.1.1.2/24	Assign IP address to interface
(config-if)#exit	Exit Interface mode
(config)#interface xe26	Enter Interface mode
(config-if)# ip address 200.1.1.1/24	Assign IP address to interface
(config-if)#exit	Exit interface mode
(config)# router bgp 200	Enter BGP router mode
(config-router)# bgp router-id 37.37.37.37	Configure BGP router-id
(config-router)#neighbor 100.1.1.1 remote-as 100	Configure PE1 as an eBGP4+ neighbor
(config-router)# address-family ipv4 unicast	Enter address-family IPv4 unicast mode
(config-router-af)# redistribute connected	Redistribute the connected route under address family IPv4 unicast
(config-router-af)# neighbor 100.1.1.1 activate	Activate the neighbor in the IPv4 address family
(config-router-af)#exit	Exit form address family
(config-router)# commit	Commit the configurations

CE2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 2.2.2.2/32 secondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#interface xe14	Enter Interface mode
(config-if)# ip address 101.1.1.2/24	Assign IP address to interface
(config-if)#exit	Exit Interface mode
(config)#interface xe15	Enter Interface mode
(config-if)# ip address 201.1.1.1/24	Assign IP address to interface
(config-if)#exit	Exit interface mode
(config)# router bgp 300	Enter BGP router mode
(config-router)# bgp router-id 2.2.2.2	Configure BGP router-id
(config-router)#neighbor 101.1.1.1 remote-as 100	Configure PE2 as an eBGP4+ neighbor
(config-router)# address-family ipv4 unicast	Enter address-family IPv4 unicast mode
(config-router-af)# redistribute connected	Redistribute the connected route under address family IPv4 unicast
(config-router-af)# neighbor 101.1.1.1 activate	Activate the neighbor in the IPv4 address family
(config-router-af)#exit	Exit form address family
(config-router)# commit	Commit the configurations

TWAMP Configuration on Sender (PE1)

TWAMP sender is configured to measure the delay on interface Loopback on PE1

#configure terminal	Enter Configure mode.
(config)# hardware-profile filter twamp-ipv4 enable	Enable hardware filter for ipv4 to configure TWAMP measurement configs
(config)#commit	Commit the configuration
(config)# twamp-light control	Enable TWAMP light controller on PE1
(config-twamp-light-con)# control-admin-state enable	Enable TWAMP Controller admin state
(config)#interface lo	Enter Interface Loopback mode
(config-if)# delay-measurement dynamic twamp reflector-ip 11.1.1.8	Configure delay measurement on interface Loopback to reflector PE2
(config-if)#commit	Commit the configurations
(config-if)#end	Return to privilege mode

TWAMP Configuration on Reflector (PE2)

Configure TWAMP Reflector as interface xe24 on PE2 (Towards core)

#configure terminal	Enter Configure mode.
(config)# hardware-profile filter twamp-ipv4 enable	Enable hardware filter for ipv4 to configure TWAMP measurement configs
(config)# commit	Commit the configuration
(config)# twamp-light reflector	Enable TWAMP light Reflector on PE2
(config-twamp-light-ref)# reflec-tor-admin-state enable	Enable the TWAMP reflector admin state
(config-twamp-light-ref)# reflector-name pe2 reflector-ip ipv4 11.1.1.8	Configure TWAMP reflector IP as PE2 interface IP
(config-twamp-light-ref)# commit	Commit the configurations
(config-if)# end	Return to privilege mode

Validation

1. Verify ping from PE1 to PE2

```
PE1#ping 11.1.1.8
Press CTRL+C to exit
PING 11.1.1.8 (11.1.1.8) 56(84) bytes of data.
64 bytes from 11.1.1.8: icmp_seq=1 ttl=63 time=0.683 ms
64 bytes from 11.1.1.8: icmp_seq=2 ttl=63 time=0.491 ms
64 bytes from 11.1.1.8: icmp_seq=3 ttl=63 time=0.594 ms
```

2. Verify mpls l3vpn ping from PE1

```
PE1#ping mpls l3vpn vrf100 101.1.1.0/24
Sending 5 MPLS Echos to 101.1.1.0, timeout is 5 seconds
```

Codes:

```
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
```

Type 'Ctrl+C' to abort

```
!
!
!
!
!
```

Success Rate is 100.00 percent (5/5)

3. Verify the TWAMP statistics on all the configured interfaces on PE1

In the below verification command, packets sent and received showing as equal. So all the TWAMP packets received reply for all the sent packets for the delay measurement. Showing all the Round Trip Delay and Reverse Delay timers.

```
PE1#sh twamp-statistics
=====
TWAMP Test-Session Statistics
=====
Test-Session Name      : __internal_interface_xe8
Start Time             : 2019 Feb 14 15:21:58
Elapsed time(milli sec) : 6003
Packets Sent           : 6
Packets Received       : 6
Packet Loss(%)         : 0.00
Round Trip Delay(usec)
  Minimum              : 17
  Maximum              : 19
  Average              : 18
Forward Delay(usec)
  Minimum              : (*)
  Maximum              : (*)
  Average              : (*)
Reverse Delay(usec)
  Minimum              : (*)
  Maximum              : (*)
  Average              : (*)
Round Trip Delay Variation(usec)
  Minimum              : 16
  Maximum              : 19
  Average              : 17
Forward Delay Variation(usec)
  Minimum              : (*)
  Maximum              : (*)
  Average              : (*)
Reverse Delay Variation(usec)
  Minimum              : (*)
  Maximum              : (*)
  Average              : (*)
```

(*) - Time is not in sync between Sender and Reflector

4. Verify the List of all interfaces that are currently participating in Delay measurement

```
PE1#sh twamp-statistics interfaces
Interface Last Advertisement Delay(us)  Min(us)  Max(us)  Var(us)  Loss(%)
Xe8      2019-02-14 15:22:00           10       10       10        0  Not Enabled
```

5. Verify the Detailed list of TWAMP delay measurement information on interface xe8

```
PE1#sh twamp-statistics interfaces xe8
Interface name      : xe8
Sender IP           : 10.1.1.18
Reflector IP        : 11.1.1.8
Reflector port      : 862
DSCP value          : 0
HW Status           : HW rules installed
Last Advertised stats:
  Time: 2019-02-14 15:22:00
  Average delay      : 10
  Minimum delay      : 10
  Maximum delay      : 10
  Average delay variation: 0
  Minimum delay variation: 0
  Maximum delay variation: 0
  Packets sent       : 1
  Packets received    : 1
  Packets timeout     : 0
  Packet Loss: Not Enabled
Last Calculated stats:
  Time: 2019-02-14 15:22:00
  Average delay      : 10
  Minimum delay      : 10
  Maximum delay      : 10
  Average delay variation: 0
  Minimum delay variation: 0
  Maximum delay variation: 0
  Packets sent       : 1
  Packets received    : 1
  Packets timeout     : 0
Packet Loss : Not Enabled
```

CHAPTER 4 DHCP Relay Agent Over L3VPN Configuration

The DHCP Relay feature was designed to forward DHCP broadcast requests as unicast packets to a configured DHCP server or servers for redundancy. In the L3VPN case, there is a special tunnel which gets created through which all the communication happens. In OcNOS, the interface created is named as tunmpls. This tunnel name is not exposed to the OcNOS control plane. This interface is directly created in the kernel.

DHCP Relay Over L3 VPN for IPv4

Before configuring DHCP Relay, make sure DHCP server and client configurations are done.

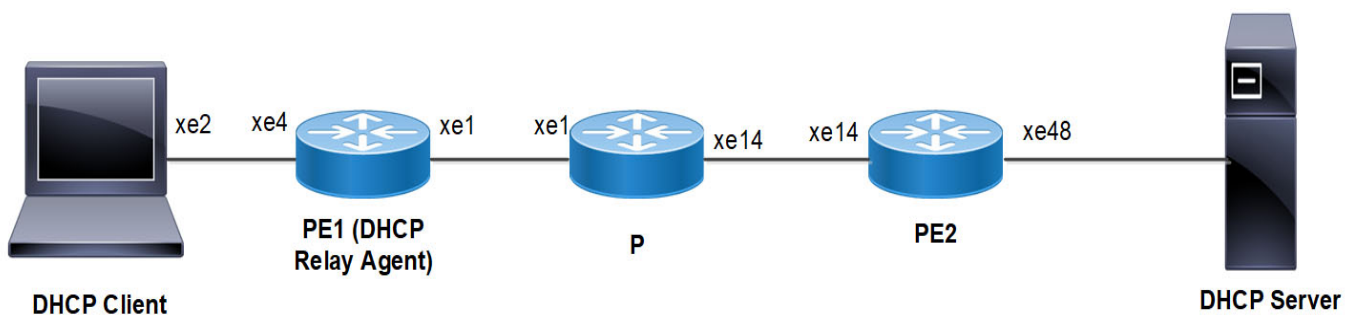


Figure 4-30: DHCP Relay Over L3 VPN Configuration

DHCP Client

#configure terminal	Enter configure mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address dhcp	Enable DHCP on interface
(config-if)#commit	Commit the candidate configuration to the running configuration

PE1 (DHCP Relay Agent)

#configure terminal	Enter configure mode.
(config)#ip dhcp relay	By default this will be enabled. It starts the ip dhcp relay service.
(config)#ip vrf vrf1	Configuring non default vrf vrf1
(config-vrf)#rd 10:10	Assign a route distinguisher to VRF
(config-vrf)#route-target both 10:10	Configure a route target for vrf1.
(config-vrf)#ip dhcp relay address 11.11.0.1	Configure DHCP server address.
(config-vrf)#ip dhcp relay uplink l3vpn	configure IPv4 DHCP Relay over L3VPN.
(config)#interface xe4	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Configure vrf forwarding for vrf1
(config-if)#ip address 50.50.50.1/24	Add IP address.
(config-if)#ip dhcp relay	Configure DHCP relay for the interface connecting to client.

(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit from interface mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 1.1.1.1/32 secondary	Set an IP address on the interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit from interface mode
(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 1.1.1.1	Configure an LDP router ID.
(config-router)#exit	Exit from Router LDP mode
(config)#interface xel	Enter interface mode
(config-if)#ip address 10.1.1.1/24	Add IP address.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on the interface.
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit from interface mode
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 1.1.1.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)# router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)# bgp router-id 1.1.1.1	Configure a fixed Router ID (1.1.1.1)
(config-router)# neighbor 3.3.3.3 remote-as 100	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 3.3.3.3 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into IPV4 unicast address family
(config-router-af)# neighbor 3.3.3.3 activate	Activate the neighbor in the IPV4 address family
(config-router-af)#exit	Exiting of Address family mode
(config-router)# address-family vpnv4 unicast	Entering into address family mode as vpnv4
(config-router-af)# neighbor 3.3.3.3 activate	Activate the neighbor in the vpnv4 address family
(config-router-af)#exit	Exiting of Address family mode
(config-router)# address-family ipv4 vrf vrf1	Entering into address family mode as ipv4 vrf vrf1
(config-router-af)# redistribute connected	Redistribute connected routes.
(config-router-af)#exit	Exiting of Address family mode
(config-router)# commit	Commit the candidate configuration to the running configuration

P

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 2.2.2.2/32 secondary	Set an IP address on the interface
(config-if)#exit	Exit from interface mode
(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 2.2.2.2	Configure an LDP router ID.
(config-router)#exit	Exit from Router LDP mode
(config)#interface xe14	Enter interface mode
(config-if)# ip address 20.1.1.1/24	Add IP address.
(config-if)# label-switching	Enable label switching on the interface
(config-if)# enable-ldp ipv4	Enable IPv4 LDP configuration on the interface.
(config-if)#exit	Exit from interface mode
(config)#interface xe1	Enter interface mode
(config-if)# ip address 10.1.1.2/24	Add IP address.
(config-if)# label-switching	Enable label switching on the interface
(config-if)# enable-ldp ipv4	Enable IPv4 LDP configuration on the interface.
(config-if)#exit	Exit from interface mode
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 3.3.3.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 20.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#network 10.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)# commit	Commit the candidate configuration to the running configuration

PE2

#configure terminal	Enter configure mode.
(config)#ip vrf vrf1	Configuring non default vrf vrf1
(config-vrf)# rd 10:10	Assign a route distinguisher to VRF
(config-vrf)# route-target both 10:10	Configure a route target for vrf1.
(config)#interface xe48	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Configure vrf forwarding for vrf1
(config-if)# commit	Commit the candidate config
(config-if)#ip address 11.11.0.2/24	Add IP address.
(config-if)#exit	Exit from interface mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Set an IP address on the interface

(config-if)#exit	Exit from interface mode
(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 3.3.3.3	Configure an LDP router ID.
(config-router)#exit	Exit from Router LDP mode
(config)#interface xe14	Enter interface mode
(config-if)# ip address 20.1.1.2/24	Add IP address.
(config-if)# label-switching	Enable label switching on the interface
(config-if)# enable-ldp ipv4	Enable IPv4 LDP configuration on the interface.
(config-if)#exit	Exit from interface mode
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 3.3.3.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 20.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)# router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)# bgp router-id 3.3.3.3	Configure a fixed Router ID (3.3.3.3)
(config-router)# neighbor 1.1.1.1 remote-as 100	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 1.1.1.1 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into IPV4 unicast address family
(config-router-af)# neighbor 1.1.1.1 activate	Activate the neighbor in the IPV4 address family
(config-router-af)#exit	Exiting of Address family mode
(config-router)# address-family vpnv4 unicast	Entering into address family mode as vpnv4
(config-router-af)# neighbor 1.1.1.1 activate	Activate the neighbor in the vpnv4 address family
(config-router-af)#exit	Exiting of Address family mode
(config-router)# address-family ipv4 vrf vrf1	Entering into address family mode as ipv4 vrf vrf1
(config-router-af)# redistribute connected	Redistribute connected routes.
(config-router-af)#exit	Exiting of Address family mode
(config-router)# commit	Commit the candidate configuration to the running configuration

Validation

PE1 (DHCP Relay Agent)

```

PE1#show running-config dhcp
ip vrf vrf1
  ip dhcp relay address 11.11.0.1
  ip dhcp relay uplink l3vpn
interface xe4

```

```
ip dhcp relay
```

```
PE1#show ip dhcp relay
DHCP relay service is Enabled.
```

```
VRF Name: vrf1
Option 82: Disabled
DHCP Servers configured: 11.11.0.1
```

Interface	Uplink/Downlink
xe4	Downlink
l3vpn	uplink

Incoming DHCPv4 packets which already contain relay agent option are FORWARDED and changed.

```
PE1#show ip dhcp relay address
VRF Name: vrf1
DHCP Servers configured: 11.11.0.1
```

Incoming DHCPv4 packets which already contain relay agent option are FORWARDED and changed.

DHCP Client

```
#show ip interface brief | include xe2
xe5    *50.50.50.2 up    up
```

DHCP Relay Over L3 VPN for IPv6

Before configuring DHCP Relay, make sure DHCP server and client configurations are done.

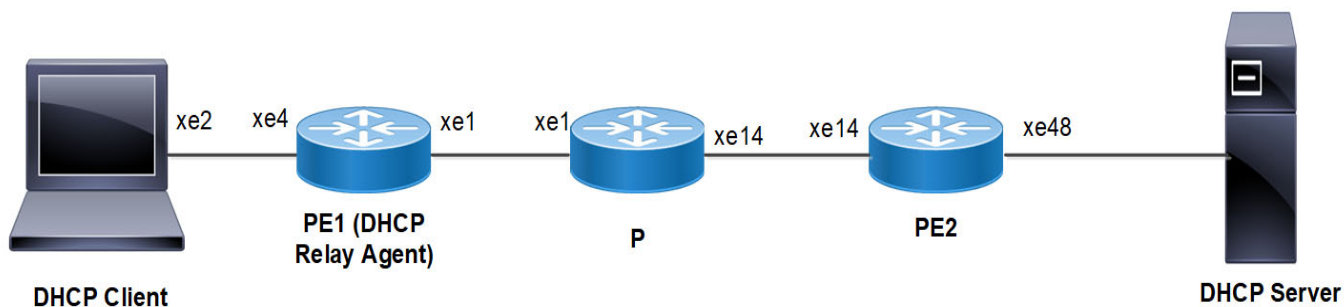


Figure 4-31: DHCP Relay Over L3 VPN Configuration

DHCP Client

#configure terminal	Enter configure mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ipv6 address dhcp	Enable DHCP on interface
(config-if)#commit	Commit the candidate configuration to the running configuration

PE1 (DHCP Relay Agent)

#configure terminal	Enter configure mode.
(config)#ipv6 dhcp relay	By default this will be enabled. It starts the ipv6 dhcp relay service.
(config)#ip vrf vrf1	Configuring non default vrf vrf1
(config-vrf)#rd 10:10	Assign a route distinguisher to VRF
(config-vrf)#route-target both 10:10	Configure a route target for vrf1.
(config-vrf)#ipv6 dhcp relay address 2002::1	Configure DHCP server address.
(config-vrf)#ipv6 dhcp relay uplink l3vpn	configure IPv6 DHCP Relay over L3VPN.
(config)#interface xe4	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Configure vrf forwarding for vrf1
(config-if)# ipv6 address 2001::1/64	Add IPv6 address.
(config-if)#ipv6 dhcp relay	Configure DHCP relay for the interface connecting to client.
(config-if)#exit	Exit from interface mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 1.1.1.1/32 secondary	Set an IP address on the interface
(config-if)#exit	Exit from interface mode
(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 1.1.1.1	Configure an LDP router ID.
(config-router)#exit	Exit from Router LDP mode
(config)#interface xe1	Enter interface mode
(config-if)# ip address 10.1.1.1/24	Add IP address.
(config-if)# label-switching	Enable label switching on the interface
(config-if)# enable-ldp ipv4	Enable IPv4 LDP configuration on the interface.
(config-if)#exit	Exit from interface mode
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 1.1.1.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)#bgp router-id 1.1.1.1	Configure a fixed Router ID (1.1.1.1)
(config-router)#neighbor 3.3.3.3 remote-as 100	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 3.3.3.3 update-source lo	Source of routing updates as loopback
(config-router)#address-family ipv4 unicast	Entering into IPV4 unicast address family
(config-router-af)#neighbor 3.3.3.3 activate	Activate the neighbor in the IPV4 address family
(config-router-af)#exit	Exiting of Address family mode
(config-router)#address-family vpnv4 unicast	Entering into address family mode as vpnv4
(config-router-af)#neighbor 3.3.3.3 activate	Activate the neighbor in the vpnv4 address family

(config-router-af)#exit	Exiting of Address family mode
(config-router)#address-family vpnv6 unicast	Entering into address family mode as vpnv6
(config-router-af)#neighbor 3.3.3.3 activate	Activate the neighbor in the vpnv6 address family
(config-router-af)#exit	Exiting of Address family mode
(config-router)# address-family ipv4 vrf vrf1	Entering into address family mode as ipv4 vrf vrf1
(config-router-af)#redistribute connected	Redistribute connected routes.
(config-router-af)#exit	Exiting of Address family mode
(config-router)# address-family ipv6 vrf vrf1	Entering into address family mode as ipv6 vrf vrf1
(config-router-af)#redistribute connected	Redistribute connected routes.
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the candidate configuration to the running configuration

P

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 2.2.2.2/32 secondary	Set an IP address on the interface
(config-if)#exit	Exit from interface mode
(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 2.2.2.2	Configure an LDP router ID.
(config-router)#exit	Exit from Router LDP mode
(config)#interface xe14	Enter interface mode
(config-if)#ip address 20.1.1.1/24	Add IP address.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on the interface.
(config-if)#exit	Exit from interface mode
(config)#interface xe1	Enter interface mode
(config-if)#ip address 10.1.1.2/24	Add IP address.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on the interface.
(config-if)#exit	Exit from interface mode
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 3.3.3.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 20.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#network 10.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)# commit	Commit the candidate configuration to the running configuration

PE2

#configure terminal	Enter configure mode.
(config)#ip vrf vrf1	Configuring non default vrf vrf1
(config-vrf)#rd 10:10	Assign a route distinguisher to VRF
(config-vrf)#route-target both 10:10	Configure a route target for vrf1.
(config)#interface xe48	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Configure vrf forwarding for vrf1
(config-if)#commit	Commit the candidate config
(config-if)#ipv6 address 2002::2/64	Add IPv6 address.
(config-if)#exit	Exit from interface mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Set an IP address on the interface
(config-if)#exit	Exit from interface mode
(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 3.3.3.3	Configure an LDP router ID.
(config-router)#exit	Exit from Router LDP mode
(config)#interface xe14	Enter interface mode
(config-if)#ip address 20.1.1.2/24	Add IP address.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on the interface.
(config-if)#exit	Exit from interface mode
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 3.3.3.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 20.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)#bgp router-id 3.3.3.3	Configure a fixed Router ID (3.3.3.3)
(config-router)#neighbor 1.1.1.1 remote-as 100	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 1.1.1.1 update-source lo	Source of routing updates as loopback
(config-router)#address-family ipv4 unicast	Entering into IPV4 unicast address family
(config-router-af)#neighbor 1.1.1.1 activate	Activate the neighbor in the IPV4 address family
(config-router-af)#exit	Exiting of Address family mode
(config-router)#address-family vpnv4 unicast	Entering into address family mode as vpnv4
(config-router-af)#neighbor 1.1.1.1 activate	Activate the neighbor in the vpnv4 address family
(config-router-af)#exit	Exiting of Address family mode
(config-router)#address-family vpnv6 unicast	Entering into address family mode as vpnv6
(config-router-af)#neighbor 1.1.1.1 activate	Activate the neighbor in the vpnv6 address family

(config-router-af)#exit	Exiting of Address family mode
(config-router)#address-family ipv4 vrf vrf1	Entering into address family mode as ipv4 vrf vrf1
(config-router-af)#redistribute connected	Redistribute connected routes.
(config-router-af)#exit	Exiting of Address family mode
(config-router)#address-family ipv6 vrf vrf1	Entering into address family mode as ipv6 vrf vrf1
(config-router-af)#redistribute connected	Redistribute connected routes.
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the candidate configuration to the running configuration

Validation

PE1 (DHCP Relay Agent)

```
PE1#show running-config dhcp
ip vrf vrf1
  ipv6 dhcp relay address 2002::1
  ipv6 dhcp relay uplink l3vpn
interface xe4
  ipv6 dhcp relay
```

```
PE1#show ipv6 dhcp relay
IPv6 DHCP relay service is Enabled.
VRF Name: vrf1
  Option 82: Enabled
  DHCPv6 Servers configured: 2002::1
  DHCPv6 IA_PD Route injection: Disabled
  Interface                Uplink/Downlink
  -----                -
  xe4                      Downlink
  l3vpn                    uplink
PE1#show ip dhcp relay address
VRF Name: vrf1
  DHCPv6 Servers configured: 2002::1
```

DHCP Client

```
#show ipv6 interface brief | include xe2
xe5    *2001::200 up    up
```

CHAPTER 5 DSCP Preserve

Overview

Layer 3 VPN services use the DSCP field in the IP header to convey QoS information, determining packet priority and treatment (e.g., DSCP 46 for high-priority voice traffic). When L3 VPN traffic enters the MPLS domain, QoS is managed by the EXP field in the MPLS label, typically derived from the DSCP value. In Qumran-based systems, the EXP field is updated based on the remarked DSCP value. By default, remarking the DSCP at the access interface affects both the IP header DSCP field and the MPLS EXP field. Service managers need control over whether to remark the DSCP or not while configuring EXP field updates.

Network operator can control preserving DSCP in the edge routers at global level or per VRF level or combination of both. To provide more control, the following DSCP preservation settings are available:

- **DSCP Preserve Global** - When DSCP preserve is enabled globally, it applies to all VRFs, preserving the DSCP value even if remarking is configured.
- **DSCP Preserve Per-VRF** - Per-VRF configuration allows DSCP preservation only for specific VPN services, offering more granular control for network administrators.

DSCP Preserve Behavior: Below table shows the way DSCP preserve global and per VRF configuration impact the DSCP value of the traffic received on the VRF of interest when dscp-to-queue profile is updated with remark DSCP option.

Table 5-15:

DSCP-preserve	per-vrf not configured	per-vrf enabled	per-vrf disabled
Global enable	preserved	preserved	not preserved
Global disable	not preserved	preserved	not preserved

Network administrators can further refine control using global or custom DSCP-to-queue profiles and policy-map configurations to remark DSCP values based on specific match criteria. This provides flexible and tailored QoS management across different VPN services.

DSCP Preserve Characteristics

- QoS information mapping ensures that the QoS information carried in the DSCP field of the IP header is correctly mapped to the MPLS EXP field.
- DSCP remarking controls whether the DSCP value in the IP header is remarked at the access interface, affecting both customer traffic and the MPLS domain.
- In hardware like Qumran, the EXP field update is based on the remarked DSCP value, requiring configuration to manage how and if DSCP values are modified.
- Ingress configuration requirement introduces the need for ingress-side configuration to properly align the DSCP and EXP field values, ensuring correct QoS handling.
- DSCP preserve provides service managers with control over whether DSCP values are modified or preserved during the process of mapping to MPLS headers.

DSCP Preserve Global

This method of configuration allows Network operator to enable or disable DSCP preserve for all the services in an edge router.

Prerequisites

The L3VPN service will operate seamlessly from end to end without any packet loss, using either OSPF or IS-IS as the IGP, with traffic profiles configured based on user-defined DSCP values.

- Globally enable dscp-preserve using the `mpls lsp-encap-dscp-preserve` command.
- Global level configuration for PE1:

```
config t
qos enable
!
qos profile dscp-to-queue profile1
dscp 24 queue 3 dscp 32
```

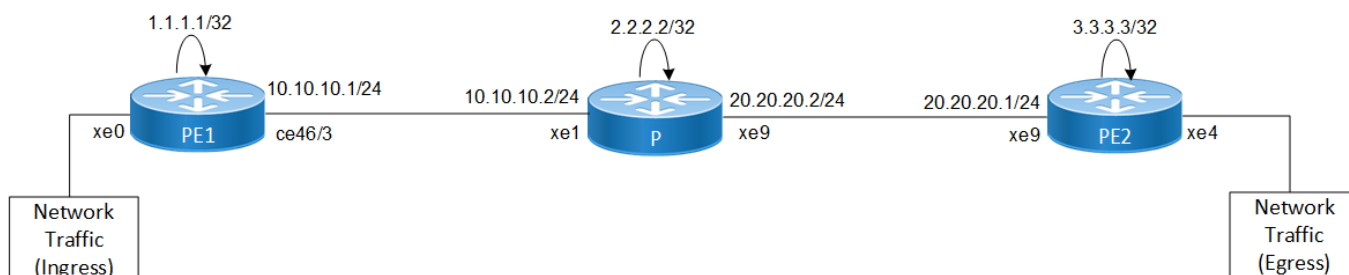
- interface level configuration for PE1:

```
interface xe3
qos map-profile dscp-to-queue profile1
!
```

Configuration for DSCP Preserve Global

Topology

The topology above illustrates the DSCP Preserve Global feature, with PE1 and PE2 serving as the edge routers for L3VPN services, and the P node acting as a transit router between them. Traffic received on PE1 with a user-defined DSCP value, which can be preserved or modified depending on the configuration applied to the ingress PE router.



DSCP Preserve Global

Configure DSCP Preserve and L3VPN Services on PE1 Router

1. Enable QoS Globally: This command enables global QoS functionality, allowing configuration of any QoS-related settings. It is mandatory to enable this feature for any QoS configurations to be effective.

```
PE1(config)#qos enable
PE1(config)#commit
```

2. Configure DSCP Preserve Globally: This command enables preserving the customer's DSCP values across the network.

```
PE1(config)#mpls lsp-encap-dscp-preserve
```

3. Configure QoS profiles or class-map profiles for remarking the incoming customer defined DSCP value to customized DSCP value.

- **Method 1: QoS Profile (dscp-to-queue):** Use a QoS profile to remap the incoming DSCP value to a user-defined queue and DSCP value.

```
PE1(config)#qos profile dscp-to-queue dscp_profile1
PE1(config-ingress-dscp-map)#dscp 24 queue 3 dscp 32
PE1(config-ingress-dscp-map)#commit
PE1(config-ingress-dscp-map)#exit
PE1(config)#Interface xe0.100
PE1(config-if)#qos map-profile dscp-to-queue dscp_profile1
PE1(config-if)#commit
PE1(config-if)#exit
```

- **Method 2: Class-Map and Policy-Map:** Use class-map and policy-map to match the incoming DSCP value and set a new DSCP value.

```
PE1(config)#class-map type qos match-any class1
PE1(config-qos-match-any)#match dscp 24
PE1(config-qos-match-any)#commit
PE1(config-qos-match-any)#exit
```

```
PE1(config)#policy-map type qos pmap1
PE1(config-pmap-qos)#class type qos class1
PE1(config-pmap-qos)#set dscp 32
PE1(config-pmap-qos)#commit
PE1(config-pmap-qos)#exit
```

```
PE1(config)#Interface xe0.100
PE1(config-if)#service-policy type qos input pmap1
PE1(config-if)#commit
```

4. Configure EXP Encapsulation on the Egress Interface: Modify the incoming EXP value to a user-defined EXP value for MPLS traffic.

- **Example config on Qumran 1:**

```
PE1(config)#qos profile exp-encap exp_profile1
PE1(config-egress-exp-encap-map)#13 dscp 32 exp 5
PE1(config-egress-exp-encap-map)#commit
PE1(config-egress-exp-encap-map)#exit
PE1(config)#interface ce46/3
PE1(config-if)#label-switching
PE1(config-if)#qos map-profile exp-encap exp_profile1
PE1(config-if)#commit
PE1(config-if)#exit
```

- **Example config on Qumran 2:**

```
PE1(config)#qos profile queue-to-exp exp_profile1
PE1(config-egress-queue-exp-map)#queue 3 color all exp 5
PE1(config-egress-queue-exp-map)#commit
PE1(config-egress-queue-exp-map)#exit
PE1(config)#interface ce46/3
PE1(config-if)#label-switching
PE1(config-if)#qos map-profile queue-to-exp exp_profile1
```

5. Define an IP VRF: Create a VRF with Route Distinguisher (RD) and Route Target (RT) to isolate customer routing information.

```
PE1(config)# ip vrf vrf100
PE1(config-vrf)# rd 1.1.1.1:100
PE1(config-vrf)# route-target both 100:100
```

```
PE1(config-vrf)#commit
```

6. Associate Interfaces with VRF: Bind interfaces to the VRF to ensure that the VRF receives the necessary routes.

```
PE1(config)#interface xe0
PE1(config-if)#ip vrf forwarding vrf100
PE1(config-if)#ip address 100.100.100.1/24
PE1(config-if)#exit
PE1(config)#commit
```

7. Configure CE Neighbor for VPN with BGP: Establish a BGP session between the PE router and the CE device, and configure it to advertise routes within the VRF.

```
PE1(config)#router bgp 100
PE1(config-router)# bgp router-id 1.1.1.1
PE1(config-router)#neighbor 3.3.3.3 remote-as 100
PE1(config-router)#neighbor 3.3.3.3 update-source lo
PE1(config-router)#neighbor 3.3.3.3 advertisement-interval 0
PE1(config-router)#address-family ipv4 unicast
PE1(config-router-af)# network 1.1.1.1/32
PE1(config-router-af)#exit-address-family
```

```
PE1(config-router)#address-family vpnv4 unicast
PE1(config-router-af)# neighbor 3.3.3.3 activate
PE1(config-router-af)#exit-address-family
```

```
PE1(config-router)#address-family ipv4 vrf vrf100
PE1(config-router-af)#redistribute connected
PE1(config-router-af)#neighbor 100.100.100.2 remote-as 100
PE1(config-router-af)#neighbor 100.100.100.2 activate
PE1(config-router-af)#exit-address-family
PE1(config-router)#commit
```

Running Configuration on PE1 Router is as follows:

```
PE1#show running-config
!
! Software version: UFI_S9600-56DX-OcNOS-SP-PLUS-6.5.3.80-Alpha 10/07/2024
14:38:44
!
! Last configuration change at 02:55:39 UTC Tue Oct 15 2024 by root
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile filter qos-ext enable
hardware-profile statistics voq-full-color enable
hardware-profile statistics cfm-ccm disable
hardware-profile port-config mode3
!
qos enable
!
qos profile dscp-to-queue dscp_profile1
dscp 24 queue 3 dscp 32
```

```
qos profile queue-to-exp exp_profile1
  queue 3 color all exp 5
!
mpls lsp-encap-dscp-preserve
!
hostname PE1
port ce46 breakout 4X10g
no ip domain-lookup
ip domain-lookup vrf management
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
!
ip vrf management
!
ip vrf vrf100
  rd 1.1.1.1:100
  route-target both 100:100
!
router ldp
  targeted-peer ipv4 3.3.3.3
  exit-targeted-peer-mode
  transport-address ipv4 1.1.1.1
!
router rsvp
!
interface ce46/3
  load-interval 30
  ip address 10.10.10.1/24
  mtu 9216
  label-switching
  enable-ldp ipv4
  enable-rsvp
!
interface eth0
  ip vrf forwarding management
  ip address dhcp
!
interface lo
  ip address 127.0.0.1/8
  ip address 1.1.1.1/32 secondary
  ipv6 address ::1/128
!
interface lo.management
  ip vrf forwarding management
  ip address 127.0.0.1/8
  ipv6 address ::1/128
!
exit
```



```

!
router ospf 100
  ospf router-id 1.1.1.1
  network 1.1.1.1/32 area 0.0.0.0
  network 10.10.10.0/24 area 0.0.0.0
!
router bgp 100
  bgp router-id 1.1.1.1
  neighbor 3.3.3.3 remote-as 100
  neighbor 3.3.3.3 update-source lo
  neighbor 3.3.3.3 advertisement-interval 0
  !
  address-family ipv4 unicast
  network 1.1.1.1/32
  exit-address-family
  !
  address-family vpnv4 unicast
  neighbor 3.3.3.3 activate
  exit-address-family
  !
  address-family ipv4 vrf vrf100
  redistribute connected
  neighbor 100.100.100.2 remote-as 100
  neighbor 100.100.100.2 activate
  exit-address-family
  !
  exit
!
line console 0
  exec-timeout 0
!
!
end

PE1#

```

Running Configuration on P Router is as follows:

```

P#show running-config
!
! Software version: EC_AS5912-54X-OcNOS-SP-MPLS-6.6.0.104-Alpha 10/13/2024
21:38:49
!
! Last configuration change at 02:00:52 UTC Tue Oct 15 2024 by root
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile statistics ingress-acl enable
!
qos enable
!

```

```
hostname P
no ip domain-lookup
ip domain-lookup vrf management
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
!
ip vrf management
!
router ldp
  transport-address ipv4 2.2.2.2
!
router rsvp
!
interface eth0
  ip vrf forwarding management
  ip address dhcp
!
interface lo
  ip address 127.0.0.1/8
  ip address 2.2.2.2/32 secondary
  ipv6 address ::1/128
!
interface lo.management
  ip vrf forwarding management
  ip address 127.0.0.1/8
  ipv6 address ::1/128
!
interface xe1
  load-interval 30
  ip address 10.10.10.2/24
  mtu 9216
  label-switching
  enable-ldp ipv4
  enable-rsvp
!
interface xe9
  load-interval 30
  ip address 20.20.20.2/24
  mtu 9216
  label-switching
  enable-ldp ipv4
  enable-rsvp
!
exit
!
router ospf 100
  ospf router-id 2.2.2.2
  network 2.2.2.2/32 area 0.0.0.0
```

```
network 10.10.10.0/24 area 0.0.0.0
network 20.20.20.0/24 area 0.0.0.0
!
line console 0
exec-timeout 0
!
!
end

P#
```

Running Configuration on PE2 Router is as follows:

```
PE2#show running-config
!
! Software version: EC_AS7316-26XB-OcNOS-CSR-6.5.3.81-Alpha 10/08/2024
14:39:39
!
! Last configuration change at 07:33:31 UTC Tue Oct 15 2024 by root
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile statistics ingress-acl enable
!
qos enable
!
hostname PE2
no ip domain-lookup
ip domain-lookup vrf management
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
!
ip vrf management
!
ip vrf vrf100
rd 3.3.3.3:100
route-target both 100:100
!
router ldp
!
router rsvp
!
```

```
interface ce0
!
interface cel
!
interface eth0
 ip vrf forwarding management
 ip address dhcp
!
interface lo
 ip address 127.0.0.1/8
 ip address 3.3.3.3/32 secondary
 ipv6 address ::1/128
!
interface lo.management
 ip vrf forwarding management
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
interface xe4.100
 encapsulation dot1q 100
 load-interval 30
 ip vrf forwarding vrf100
 ip address 200.200.200.1/24
 mtu 9216
!
interface xe9
 load-interval 30
 ip address 20.20.20.1/24
 mtu 9216
 label-switching
 enable-ldp ipv4
!
exit
!
router ospf 100
 ospf router-id 3.3.3.3
 network 3.3.3.3/32 area 0.0.0.0
 network 20.20.20.0/24 area 0.0.0.0
!
router bgp 100
 bgp router-id 3.3.3.3
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source lo
 neighbor 1.1.1.1 advertisement-interval 0
!
 address-family ipv4 unicast
  network 3.3.3.3/32
 exit-address-family
!
 address-family vpnv4 unicast
  neighbor 1.1.1.1 activate
 exit-address-family
!
 address-family ipv4 vrf vrf100
  redistribute connected
  neighbor 200.200.200.2 remote-as 100
  neighbor 200.200.200.2 activate
```

```

    exit-address-family
    !
    exit
    !
    line console 0
    exec-timeout 0
    !
    !
    end
    PE2#

```

Validation

Below show command gives us the output of ospf neighborship with transit node.

```
PE1#show ip ospf neighbor
```

Total number of full neighbors: 1

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
2.2.2.2	1	Full/DR	00:00:37	10.10.10.2	ce46/3	0

```
PE1#
```

```
PE1#sh ip vrf
```

VRF management, VRF ID: 1, FIB ID 1

MPLS DSCP Preserve Enabled (global)

Router ID: 10.12.96.29 (automatic)

Interfaces:

eth0

lo.management

!

VRF vrf100, VRF ID: 2, FIB ID 2

MPLS DSCP Preserve Enabled (global)

Router ID: 100.100.100.1 (automatic)

Interfaces:

lo.vrf100

xe0.100

!

Total Number of configured IP VRF's: 2

Total Number of all VRF's: 3

Name	Default RD
management	not set
vrf100	1.1.1.1:100

```
PE1#
```

```
PE1#show ip bgp summary
```

BGP router identifier 100.100.100.1, local AS number 100

BGP VRF vrf100 Route Distinguisher: 1.1.1.1:100

BGP table version is 5

1 BGP AS-PATH entries

0 BGP community entries

Neighbor PfxRcd Desc	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
100.100.100.2 10	4	100	116	131	5	0	0	00:01:06	

Total number of neighbors 1

Total number of Established sessions 1
PE1#

```
PE1#show ip bgp vpnv4 all summary
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 3
1 BGP AS-PATH entries
0 BGP community entries
```

Neighbor PfxRcd Desc	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
3.3.3.3 1	4	100	139	141	2	0	0	00:00:28	

Total number of neighbors 1

Total number of Established sessions 1

```
BGP VRF vrf100 Route Distinguisher: 1.1.1.1:100
BGP table version is 5
1 BGP AS-PATH entries
0 BGP community entries
```

Neighbor PfxRcd Desc	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
100.100.100.2 10	4	100	116	131	5	0	0	00:01:12	

Total number of neighbors 1

Total number of Established sessions 1
PE1#

Below show commands gives us the traffic statistics. Xe0.100 is ingress interface and ce46/3 is the egress interface.

```
PE1#show interface counters rate mbps
```

Interface	Rx mbps	Rx pps	Tx mbps	Tx pps

```
ce46/3          0.00          0          10.36          9810
xe0             10.21         9969          0.00          0
xe0.100         10.25        10007          0.00          0
PE1#
```

Below show command gives us the queue-stats on the egress interface of the ingress node. From the configuration made, the traffic is expected to flow in queue 3 as shown below.

```
PE1#show interface ce46/3 counters queue-stats
E - Egress, I - Ingress, Q-Size is in bytes
+-----+-----+-----+-----+-----+
+-----+
| Queue/Class-map | Q-Size | Tx pkts | Tx bytes | Dropped pkts |
Dropped bytes |
+-----+-----+-----+-----+-----+
+-----+
q0              (E) 12499968 0          0          0          0
q1              (E) 12499968 0          0          0          0
q2              (E) 12499968 0          0          0          0
q3              (E) 12499968 7931421    872455900    0          0
q4              (E) 12499968 0          0          0          0
q5              (E) 12499968 0          0          0          0
q6              (E) 12499968 377        30275       0          0
q7              (E) 12499968 252        14180       0          0
PE1#
```

Once the end to end traffic is verified, capture the packet on egress interface of the ingress node. Below is the example packet capture.

100.100.100.2 → 200.200.200.2 IPv4 Unknown (253)

68	21	5F	1F	52	21	5C	07	58	51	13	42	88	47	06	68
08	40	06	B8	09	40	45	60	00	6A	CB	85	00	00	FE	FD
96	7F	64	64	64	02	C8	C8	C8	02	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	7A	50	DE	BE
BB	F7	F9	31	20	D9	5F	8C	19	3E	FB	D4	91	B2	CA	9B

4 protocols in packet:

EthernetMPLSMPLSIPv4

Below snapshot is the decoded output of the packet capture. Here we can see that EXP bit is 4 and preserved DSCP value is 24.

```

* Frame 1: 128 bytes on wire (1024 bits)
* Ethernet II
* MultiProtocol Label Switching Header
  * 0000 0110 0110 1000 0000 .... = MPLS Label: 26240 (0x06680)
  * ..... 100. .... = MPLS Experimental Bits: 4
  * .....0 ..... = MPLS Bottom Of Label Stack: 0
  * ..... 0100 0000 = MPLS TTL: 64
* MultiProtocol Label Switching Header
* Internet Protocol Version 4
  * 0100 .... = Version: 4
  * .... 0101 = Header Length: 20 bytes (5)
  * Differentiated Services Field: 0x60 (DSCP: CS3, ECN: Not-ECT)
    * 0110 00.. = Differentiated Services Codepoint: Class Selector 3 (24)
    * .... ..00 = Explicit Congestion Notification: Not ECN-Capable Transport (0)
  * Total Length: 106
  * Identification: 0xcb85 (52101)
  * 000. .... = Flags: 0x0
  * ...0 0000 0000 0000 = Fragment Offset: 0
  * Time to Live: 254
  * Protocol: Unknown (253)
  * Header Checksum: 0x967f
  * Header checksum status: Unverified
  * Source Address: 100.100.100.2
  * Destination Address: 200.200.200.2
  * Stream index: 0

```

```
PE1#show qos-profile type dscp-to-queue dscp_profile1
```

```
profile name: dscp_profile1
```

```
profile type: dscp-to-queue
```

```
profile attached to 1 instances
```

```
configured mapping:
```

```
  dscp 24 queue 3 dscp 32
```

```
Detailed mapping:
```

INPUT				OUTPUT				INPUT				OUTPUT				INPUT			
OUTPUT				INPUT				OUTPUT				INPUT				OUTPUT			
DSCP	TC	Color	remark	DSCP	TC	Color	remark	DSCP	TC	Color	remark	DSCP	TC	Color	remark	DSCP	TC	Color	remark
(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)
0	0	green	0 (0)	16	2	green	16 (2)	32	4										
green	32 (4)		48	6	green	48 (6)													
1	0	green	1 (0)	17	2	green	17 (2)	33	4										
green	33 (4)		49	6	green	49 (6)													

2	0	green	2 (0)		18	2	green	18 (2)		34	4
green	34 (4)		50	6	green	50 (6)					
3	0	green	3 (0)		19	2	green	19 (2)		35	4
green	35 (4)		51	6	green	51 (6)					
4	0	green	4 (0)		20	2	yellow	20 (2)		36	4
yellow	36 (4)		52	6	green	52 (6)					
5	0	green	5 (0)		21	2	green	21 (2)		37	4
green	37 (4)		53	6	green	53 (6)					
6	0	green	6 (0)		22	2	yellow	22 (2)		38	4
yellow	38 (4)		54	6	green	54 (6)					
7	0	green	7 (0)		23	2	green	23 (2)		39	4
green	39 (4)		55	6	green	55 (6)					
8	1	green	8 (1)		24	3	green	32 (4)		40	5
green	40 (5)		56	7	green	56 (7)					
9	1	green	9 (1)		25	3	green	25 (3)		41	5
green	41 (5)		57	7	green	57 (7)					
10	1	green	10 (1)		26	3	green	26 (3)		42	5
green	42 (5)		58	7	green	58 (7)					
11	1	green	11 (1)		27	3	green	27 (3)		43	5
green	43 (5)		59	7	green	59 (7)					
12	1	yellow	12 (1)		28	3	yellow	28 (3)		44	5
green	44 (5)		60	7	green	60 (7)					
13	1	green	13 (1)		29	3	green	29 (3)		45	5
green	45 (5)		61	7	green	61 (7)					
14	1	yellow	14 (1)		30	3	yellow	30 (3)		46	5
green	46 (5)		62	7	green	62 (7)					
15	1	green	15 (1)		31	3	green	31 (3)		47	5
green	47 (5)		63	7	green	63 (7)					

PE1#

PE1#show qos-profile interface ce46/3

profile name: default

profile type: dscp-to-queue (Ingress)

mapping:

INPUT				OUTPUT				INPUT				OUTPUT				INPUT				OUTPUT			
DSCP	TC	Color	remark	DSCP	DSCP	TC	Color	remark	DSCP	DSCP	TC	Color	remark	DSCP	DSCP	TC	Color	remark	DSCP	DSCP	TC	Color	remark
(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)	(TC)
0	0	green	0 (0)		16	2	green	16 (2)		32	4												
green	32 (4)		48	6	green	48 (6)																	
1	0	green	1 (0)		17	2	green	17 (2)		33	4												
green	33 (4)		49	6	green	49 (6)																	
2	0	green	2 (0)		18	2	green	18 (2)		34	4												
green	34 (4)		50	6	green	50 (6)																	

3	0	green	3 (0)		19	2	green	19 (2)		35	4
green	35 (4)		51	6	green	51 (6)					
4	0	green	4 (0)		20	2	yellow	20 (2)		36	4
yellow	36 (4)		52	6	green	52 (6)					
5	0	green	5 (0)		21	2	green	21 (2)		37	4
green	37 (4)		53	6	green	53 (6)					
6	0	green	6 (0)		22	2	yellow	22 (2)		38	4
yellow	38 (4)		54	6	green	54 (6)					
7	0	green	7 (0)		23	2	green	23 (2)		39	4
green	39 (4)		55	6	green	55 (6)					
8	1	green	8 (1)		24	3	green	24 (3)		40	5
green	40 (5)		56	7	green	56 (7)					
9	1	green	9 (1)		25	3	green	25 (3)		41	5
green	41 (5)		57	7	green	57 (7)					
10	1	green	10 (1)		26	3	green	26 (3)		42	5
green	42 (5)		58	7	green	58 (7)					
11	1	green	11 (1)		27	3	green	27 (3)		43	5
green	43 (5)		59	7	green	59 (7)					
12	1	yellow	12 (1)		28	3	yellow	28 (3)		44	5
green	44 (5)		60	7	green	60 (7)					
13	1	green	13 (1)		29	3	green	29 (3)		45	5
green	45 (5)		61	7	green	61 (7)					
14	1	yellow	14 (1)		30	3	yellow	30 (3)		46	5
green	46 (5)		62	7	green	62 (7)					
15	1	green	15 (1)		31	3	green	31 (3)		47	5
green	47 (5)		63	7	green	63 (7)					

profile name: default
profile type: dscp-to-dscp (Egress)
Status: Inactive
mapping:

INPUT				OUTPUT	INPUT				OUTPUT	INPUT	
OUTPUT											
Remark DSCP	Color	Out DSCP			Remark DSCP	Color	Out DSCP			Remark DSCP	
Color	Out DSCP				Color	Out DSCP				Color	Out DSCP
(TC)					(TC)					(TC)	
0 (0)	green	0		0 (0)	yellow	0		0 (0)			
red	0										
1 (0)	green	1		1 (0)	yellow	1		1 (0)			
red	1										
2 (0)	green	2		2 (0)	yellow	2		2 (0)			
red	2										
3 (0)	green	3		3 (0)	yellow	3		3 (0)			
red	3										
4 (0)	green	4		4 (0)	yellow	4		4 (0)			
red	4										
5 (0)	green	5		5 (0)	yellow	5		5 (0)			
red	5										

6 (0) red	green 6	6	6 (0)	yellow	6	6 (0)
7 (0) red	green 7	7	7 (0)	yellow	7	7 (0)
8 (1) red	green 8	8	8 (1)	yellow	8	8 (1)
9 (1) red	green 9	9	9 (1)	yellow	9	9 (1)
10 (1) red	green 14	10	10 (1)	yellow	12	10 (1)
11 (1) red	green 11	11	11 (1)	yellow	11	11 (1)
12 (1) red	green 14	12	12 (1)	yellow	12	12 (1)
13 (1) red	green 13	13	13 (1)	yellow	13	13 (1)
14 (1) red	green 14	14	14 (1)	yellow	14	14 (1)
15 (1) red	green 15	15	15 (1)	yellow	15	15 (1)
16 (2) red	green 16	16	16 (2)	yellow	16	16 (2)
17 (2) red	green 17	17	17 (2)	yellow	17	17 (2)
18 (2) red	green 22	18	18 (2)	yellow	20	18 (2)
19 (2) red	green 19	19	19 (2)	yellow	19	19 (2)
20 (2) red	green 22	20	20 (2)	yellow	20	20 (2)
21 (2) red	green 21	21	21 (2)	yellow	21	21 (2)
22 (2) red	green 22	22	22 (2)	yellow	22	22 (2)
23 (2) red	green 23	23	23 (2)	yellow	23	23 (2)
24 (3) red	green 24	24	24 (3)	yellow	24	24 (3)
25 (3) red	green 25	25	25 (3)	yellow	25	25 (3)
26 (3) red	green 30	26	26 (3)	yellow	28	26 (3)
27 (3) red	green 27	27	27 (3)	yellow	27	27 (3)
28 (3) red	green 30	28	28 (3)	yellow	28	28 (3)
29 (3) red	green 29	29	29 (3)	yellow	29	29 (3)
30 (3) red	green 30	30	30 (3)	yellow	30	30 (3)
31 (3) red	green 31	31	31 (3)	yellow	31	31 (3)
32 (4) red	green 32	32	32 (4)	yellow	32	32 (4)
33 (4) red	green 33	33	33 (4)	yellow	33	33 (4)

34 (4) red	green 38	34 34 (4)	yellow	36 34 (4)
35 (4) red	green 35	35 35 (4)	yellow	35 35 (4)
36 (4) red	green 38	36 36 (4)	yellow	36 36 (4)
37 (4) red	green 37	37 37 (4)	yellow	37 37 (4)
38 (4) red	green 38	38 38 (4)	yellow	38 38 (4)
39 (4) red	green 39	39 39 (4)	yellow	39 39 (4)
40 (5) red	green 40	40 40 (5)	yellow	40 40 (5)
41 (5) red	green 41	41 41 (5)	yellow	41 41 (5)
42 (5) red	green 42	42 42 (5)	yellow	42 42 (5)
43 (5) red	green 43	43 43 (5)	yellow	43 43 (5)
44 (5) red	green 44	44 44 (5)	yellow	44 44 (5)
45 (5) red	green 45	45 45 (5)	yellow	45 45 (5)
46 (5) red	green 46	46 46 (5)	yellow	46 46 (5)
47 (5) red	green 47	47 47 (5)	yellow	47 47 (5)
48 (6) red	green 48	48 48 (6)	yellow	48 48 (6)
49 (6) red	green 49	49 49 (6)	yellow	49 49 (6)
50 (6) red	green 50	50 50 (6)	yellow	50 50 (6)
51 (6) red	green 51	51 51 (6)	yellow	51 51 (6)
52 (6) red	green 52	52 52 (6)	yellow	52 52 (6)
53 (6) red	green 53	53 53 (6)	yellow	53 53 (6)
54 (6) red	green 54	54 54 (6)	yellow	54 54 (6)
55 (6) red	green 55	55 55 (6)	yellow	55 55 (6)
56 (7) red	green 56	56 56 (7)	yellow	56 56 (7)
57 (7) red	green 57	57 57 (7)	yellow	57 57 (7)
58 (7) red	green 58	58 58 (7)	yellow	58 58 (7)
59 (7) red	green 59	59 59 (7)	yellow	59 59 (7)
60 (7) red	green 60	60 60 (7)	yellow	60 60 (7)
61 (7) red	green 61	61 61 (7)	yellow	61 61 (7)

62 (7)	green	62	62 (7)	yellow	62	62 (7)
red	62					
63 (7)	green	63	63 (7)	yellow	63	63 (7)
red	63					

PE1#

CLI Commands

The DSCP preserve introduces the following configuration commands.

mpls lsp-encap-dscp-preserve

Use this command to preserve DSCP for IP packets encapsulated into MPLS headers when dscp is remarked on access interface. By default, DSCP is not preserved for IP packets encapsulated into MPLS headers.

Use the no parameter with this to unconfigure DSCP preserve.

Note: In Qumran1 devices, DSCP preserve feature is not supported when the transport is Segment Routing.

Command Syntax

```
mpls lsp-encap-dscp-preserve
no mpls lsp-encap-dscp-preserve
```

Default

By default, mpls local packet handling is disabled

Parameters

None

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 6.5.2 for Qumran 1. Extended the support for Qumran 2 in OcNOS version 6.5.3.

Examples

```
#configure terminal
(config)#mpls lsp-encap-dscp-preserve
(config)#commit

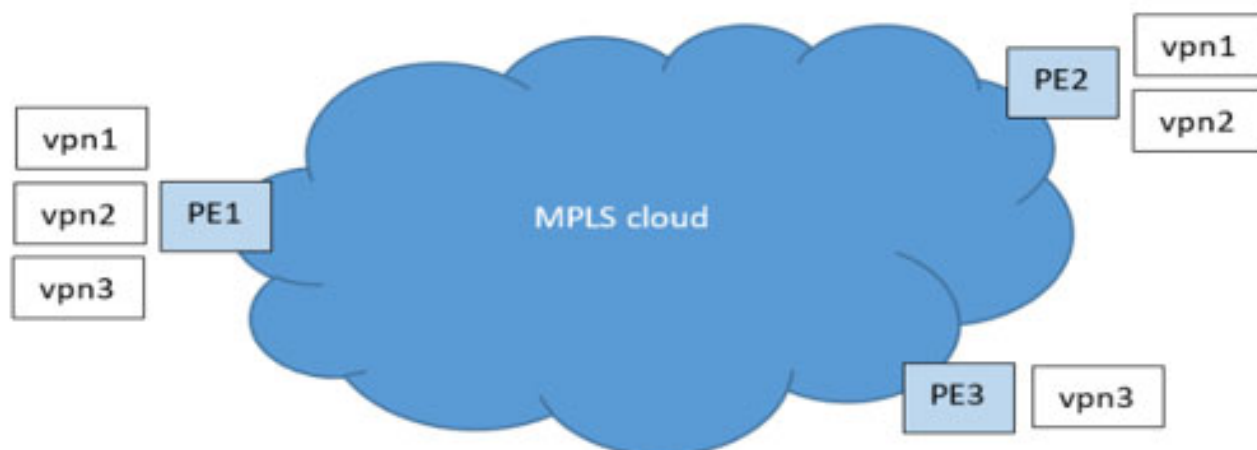
#configure terminal
(config)#no mpls lsp-encap-dscp-preserve
(config)#commit
```

DSCP Preserve Per-VRF

This method of configuration allows Network operator to enable or disable DSCP preserve for specific L3 VPN services in an edge router.

DSCP Preserve Per-VRF Characteristics

The MPLS cloud connects edge routers that provision L3 VPN services for multiple customers. Each edge router can support multiple VPN services, with different QoS (DSCP) remarking needs. Some customers may want to retain the DSCP field in the IP header, while others may need to update it as traffic enters the MPLS network. By default, the DSCP field in customer packets is not preserved when remarking occurs.



Prerequisites

The L3VPN service will operate seamlessly from end to end without any packet loss, using either OSPF or IS-IS as the IGP, with traffic profiles configured based on user-defined DSCP values.

- Global level configuration for PE1:


```

config t
qos enable
!
qos profile dscp-to-queue profile1
dscp 24 queue 3 dscp 32
      
```
- interface level configuration for PE1:

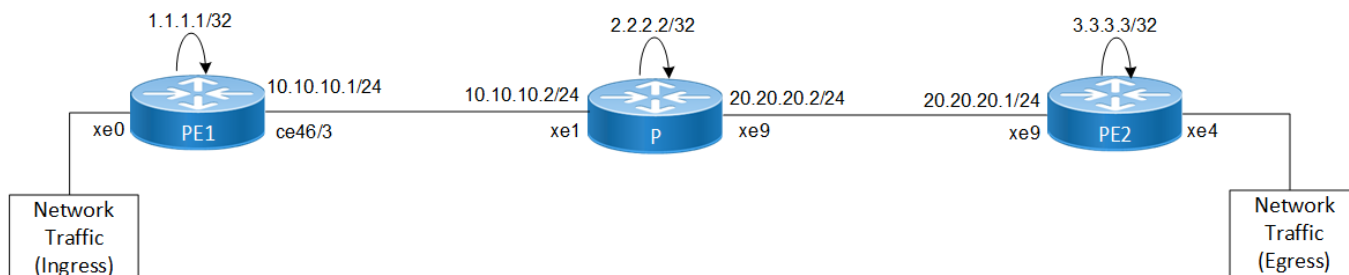

```

interface xe3
qos map-profile dscp-to-queue profile1
!
      
```

Configuration for DSCP Preserve Per-VRF

Topology

The topology illustrates the DSCP preserve feature, with PE1 and PE2 as the edge routers running L3VPN services, and the P router functioning as a transit router between them. PE1 receiving L3VPN and 6PE traffic with user-defined DSCP values, which can be either preserved or modified depending on the configurations applied at the ingress PE router. Multiple VRFs will be configured, each representing a different customer, where DSCP-preserve can be enabled or disabled at the per-VRF level.



Per- VRF DSCP Preserve

Configure DSCP Preserve and L3VPN Services on PE1 Router

1. Enable QoS Globally: This command is mandatory to configure any QoS-related settings. Without it, QoS configurations will not function.


```
PE1(config)# qos enable
PE1(config)# commit
```
2. (Optional) Configure DSCP Preserve globally for L3VPN and 6PE Traffic: This command provides control over remarking user-defined DSCP values. Enabling this will preserve the DSCP value throughout the network. If DSCP preserve to be enabled only for specific L3 VPN services, then this command need not to be configured.


```
PE1(config)#mpls lsp-encap-dscp-preserve
```
3. Configure DSCP Preserve globally for 6PE Traffic: This command provides control over remarking user-defined DSCP values. Enabling this will preserve the DSCP value throughout the network.


```
PE1(config)# mpls 6pe lsp-encap-dscp-preserve (enable | disable)
```
4. Configure QoS Profiles or Class-Map Profiles for remarking incoming DSCP values as follows:
 - Method 1: QoS Profile: Use the “dscp-to-queue” profile to remark the incoming DSCP value via a user-defined queue.


```
PE1(config)# qos profile dscp-to-queue dscp_profile1
PE1(config-ingress-dscp-map)# dscp 24 queue 3 dscp 32
PE1(config-ingress-dscp-map)# commit
PE1(config-ingress-dscp-map)# exit
PE1(config)# interface xe0.100
PE1(config-if)# qos map-profile dscp-to-queue dscp_profile1
PE1(config-if)# commit
PE1(config-if)# exit
```
 - Method 2: Class-Map/Policy-Map: Use the “match” criteria to remark the incoming DSCP value to a user-defined DSCP value.


```
PE1(config)# class-map type qos match-any class1
PE1(config-qos-match-any)# match dscp 24
```

```

PE1(config-qos-match-any)# commit
PE1(config-qos-match-any)# exit
PE1(config)# policy-map type qos pmap1
PE1(config-pmap-qos)# class type qos class1
PE1(config-pmap-qos)# set dscp 32
PE1(config-pmap-qos)# commit
PE1(config-pmap-qos)# exit
PE1(config)# interface xe0.100
PE1(config-if)# service-policy type qos input pmap1
PE1(config-if)# commit

```

5. **Configure EXP Encapsulation on the Egress Interface:** This profile modifies the incoming EXP value to the user-defined EXP value, which is then reflected in the MPLS EXP bit.

- **Example Config on Qumran 1:**

```

PE1(config)# qos profile exp-encap exp_profile1
PE1(config-egress-exp-encap-map)# 13 dscp 32 exp 5
PE1(config-egress-exp-encap-map)# commit
PE1(config-egress-exp-encap-map)# exit
PE1(config)# interface ce46/3
PE1(config-if)# label-switching
PE1(config-if)# qos map-profile exp-encap exp_profile1
PE1(config-if)# commit
PE1(config-if)# exit

```

- **Example Config on Qumran 2:**

```

PE1(config)# qos profile queue-to-exp exp_profile1
PE1(config-egress-queue-exp-map)# queue 3 color all exp 5
PE1(config-egress-queue-exp-map)# commit
PE1(config-egress-queue-exp-map)# exit
PE1(config)# interface ce46/3
PE1(config-if)# label-switching
PE1(config-if)# qos map-profile queue-to-exp exp_profile1

```

6. **Define Multiple IP VRFs:** Configure VRFs with appropriate Route Distinguisher (RD) and Route Target (RT) values to isolate IP address routing for multiple customers.

```

PE1(config)# ip vrf vrf100
PE1(config-vrf)# rd 1.1.1.1:100
PE1(config-vrf)# route-target both 100:100
PE1(config-vrf)# commit

```

```

PE1(config)# ip vrf vrf101
PE1(config-vrf)# rd 1.1.1.1:101
PE1(config-vrf)# route-target both 101:101
PE1(config-vrf)# commit

```

```

PE1(config)# ip vrf vrf102
PE1(config-vrf)# rd 1.1.1.1:102
PE1(config-vrf)# route-target both 102:102
PE1(config-vrf)# commit

```

7. **Associate Interfaces to VRFs:** After defining the VRFs, assign interfaces to them to allow the PE router to recognize which interfaces belong to each VRF.

```

PE1(config)# interface xe0.100
PE1(config-if)# encapsulation dot1q 100
PE1(config-if)# ip vrf forwarding vrf100
PE1(config-if)# ip address 100.100.100.1/24
PE1(config-if)# exit

```



```

PE1(config)# commit

PE1(config)# interface xe0.101
PE1(config-if)# encapsulation dot1q 101
PE1(config-if)# ip vrf forwarding vrf101
PE1(config-if)# ip address 100.100.101.1/24
PE1(config-if)# exit
PE1(config)# commit

PE1(config)# interface xe0.102
PE1(config-if)# encapsulation dot1q 102
PE1(config-if)# ip vrf forwarding vrf102
PE1(config-if)# ip address 100.100.102.1/24
PE1(config-if)# exit
PE1(config)# commit

PE1(config)# interface xe0.103
PE1(config-if)# encapsulation dot1q 103
PE1(config-if)# ipv6 address 1001::2/64
PE1(config-if)# exit
PE1(config)# commit

```

8. **Configure CE Neighbor for VPN Using BGP:** To provide a VPN service, configure the PE router to associate any routing information learned from a VPN customer interface with a particular VRF.

```

PE1(config)# router bgp 100
PE1(config)# bgp router-id 1.1.1.1
PE1(config)# neighbor 3.3.3.3 remote-as 100
PE1(config)# neighbor 3.3.3.3 update-source lo
PE1(config)# neighbor 3.3.3.3 advertisement-interval 0
PE1(config)# neighbor 1001::2 remote-as 100
PE1(config-router)# address-family ipv4 unicast
PE1(config-router-af)# redistribute connected
PE1(config-router-af)# exit-address-family
PE1(config-router)# address-family ipv4 vrf vrf100
PE1(config-router)# neighbor 100.100.100.2 remote-as 100
PE1(config-router-af)# neighbor 100.100.100.2 activate
PE1(config-router-af)# exit-address-family
PE1(config-router)# address-family ipv4 vrf vrf101
PE1(config-router)# neighbor 100.100.101.2 remote-as 100
PE1(config-router-af)# neighbor 100.100.101.2 activate
PE1(config-router-af)# exit-address-family
PE1(config-router)# address-family ipv4 vrf vrf102
PE1(config-router)# neighbor 100.100.102.2 remote-as 100
PE1(config-router-af)# neighbor 100.100.102.2 activate
PE1(config-router-af)# exit-address-family
PE1(config-router)# address-family ipv6 unicast
PE1(config-router-af)# neighbor 1001::2 activate
PE1(config-router-af)# exit-address-family
PE1(config-router)# commit

```

9. **Now enable or disable dscp-preserve based on requirement globally and per-vrf level for L3VPN and 6PE traffic.**

```

PE1(config)#ip vrf vrf100
PE1(config-vrf)#mpls lsp-encap-dscp-preserve enable
PE1(config)#ip vrf vrf101
PE1(config-vrf)#mpls lsp-encap-dscp-preserve disable
PE1(config)#ip vrf vrf102
PE1(config-vrf)#mpls lsp-encap-dscp-preserve enable

```

Running Configuration on PE1 Router is as follows:

```
PE1#show running-config
!
! Software version: UFI_S9600-56DX-OCNOS-SP-PLUS-6.5.3.80-Alpha 10/07/2024
14:38:44
!
! Last configuration change at 02:55:39 UTC Tue Oct 15 2024 by root
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile filter qos-ext enable
hardware-profile statistics voq-full-color enable
hardware-profile statistics cfm-ccm disable
hardware-profile port-config mode3
!
qos enable
qos profile dscp-to-queue dscp_profile1
  dscp 24 queue 3 dscp 32
qos profile queue-to-exp exp_profile1
  queue 3 color all exp 5
!
mpls lsp-encap-dscp-preserve
!
hostname PE1
port ce46 breakout 4X10g
no ip domain-lookup
ip domain-lookup vrf management
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
!
ip vrf management
!
ip vrf vrf100
  rd 1.1.1.1:100
  route-target both 100:100
!
router ldp
  targeted-peer ipv4 3.3.3.3
  exit-targeted-peer-mode
  transport-address ipv4 1.1.1.1
!
```

```
router rsvp
!
interface ce46/3
 load-interval 30
 ip address 10.10.10.1/24
 mtu 9216
 label-switching
 enable-ldp ipv4
 enable-rsvp
!
interface eth0
 ip vrf forwarding management
 ip address dhcp
!
interface lo
 ip address 127.0.0.1/8
 ip address 1.1.1.1/32 secondary
 ipv6 address ::1/128
!
interface lo.management
 ip vrf forwarding management
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
exit
!
router ospf 100
 ospf router-id 1.1.1.1
 network 1.1.1.1/32 area 0.0.0.0
 network 10.10.10.0/24 area 0.0.0.0
!
router bgp 100
 bgp router-id 1.1.1.1
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source lo
 neighbor 3.3.3.3 advertisement-interval 0
!
 address-family ipv4 unicast
  network 1.1.1.1/32
 exit-address-family
!
 address-family vpnv4 unicast
  neighbor 3.3.3.3 activate
 exit-address-family
!
 address-family ipv4 vrf vrf100
  redistribute connected
  neighbor 100.100.100.2 remote-as 100
  neighbor 100.100.100.2 activate
 exit-address-family
!
exit
!
line console 0
 exec-timeout 0
!
!
```

end

PE1#

Running Configuration on P Router is as follows:

```
P#show running-config
!
! Software version: EC_AS5912-54X-OcNOS-SP-MPLS-6.6.0.104-Alpha 10/13/2024
21:38:49
!
! Last configuration change at 02:00:52 UTC Tue Oct 15 2024 by root
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile statistics ingress-acl enable
!
qos enable
!
hostname P
no ip domain-lookup
ip domain-lookup vrf management
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
!
ip vrf management
!
router ldp
  transport-address ipv4 2.2.2.2
!
router rsvp
!
interface eth0
  ip vrf forwarding management
  ip address dhcp
!
interface lo
  ip address 127.0.0.1/8
  ip address 2.2.2.2/32 secondary
  ipv6 address ::1/128
!
```

```
interface lo.management
 ip vrf forwarding management
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
interface xe1
 load-interval 30
 ip address 10.10.10.2/24
 mtu 9216
 label-switching
 enable-ldp ipv4
 enable-rsvp
!
interface xe9
 load-interval 30
 ip address 20.20.20.2/24
 mtu 9216
 label-switching
 enable-ldp ipv4
 enable-rsvp
!
exit
!
router ospf 100
 ospf router-id 2.2.2.2
 network 2.2.2.2/32 area 0.0.0.0
 network 10.10.10.0/24 area 0.0.0.0
 network 20.20.20.0/24 area 0.0.0.0
!
line console 0
 exec-timeout 0
!
!
end

P#
```

Running Configuration on PE2 Router is as follows:

```
PE2#show running-config
!
! Software version: EC_AS7316-26XB-OcNOS-CSR-6.5.3.81-Alpha 10/08/2024
14:39:39
!
! Last configuration change at 07:33:31 UTC Tue Oct 15 2024 by root
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile statistics ingress-acl enable
!
qos enable
```

```
!  
hostname PE2  
no ip domain-lookup  
ip domain-lookup vrf management  
tfo Disable  
errdisable cause stp-bpdu-guard  
no feature telnet vrf management  
no feature telnet  
feature ssh vrf management  
no feature ssh  
feature dns relay  
ip dns relay  
ipv6 dns relay  
feature ntp vrf management  
ntp enable vrf management  
!  
ip vrf management  
!  
ip vrf vrf100  
  rd 3.3.3.3:100  
  route-target both 100:100  
!  
router ldp  
!  
router rsvp  
!  
interface ce0  
!  
interface cel  
!  
interface eth0  
  ip vrf forwarding management  
  ip address dhcp  
!  
interface lo  
  ip address 127.0.0.1/8  
  ip address 3.3.3.3/32 secondary  
  ipv6 address ::1/128  
!  
interface lo.management  
  ip vrf forwarding management  
  ip address 127.0.0.1/8  
  ipv6 address ::1/128  
!  
interface xe4.100  
  encapsulation dot1q 100  
  load-interval 30  
  ip vrf forwarding vrf100  
  ip address 200.200.200.1/24  
  mtu 9216  
!  
interface xe9  
  load-interval 30  
  ip address 20.20.20.1/24  
  mtu 9216  
  label-switching  
  enable-ldp ipv4
```

```

!
exit
!
router ospf 100
  ospf router-id 3.3.3.3
  network 3.3.3.3/32 area 0.0.0.0
  network 20.20.20.0/24 area 0.0.0.0
!
router bgp 100
  bgp router-id 3.3.3.3
  neighbor 1.1.1.1 remote-as 100
  neighbor 1.1.1.1 update-source lo
  neighbor 1.1.1.1 advertisement-interval 0
  !
  address-family ipv4 unicast
  network 1.1.1.1/32
  exit-address-family
  !
  address-family vpnv4 unicast
  neighbor 1.1.1.1 activate
  exit-address-family
  !
  address-family ipv4 vrf vrf100
  redistribute connected
  neighbor 200.200.200.2 remote-as 100
  neighbor 200.200.200.2 activate
  exit-address-family
  !
  exit
!
line console 0
  exec-timeout 0
!
!
end
PE2#

```

Validation

```
PE1#show ip ospf neighbor
```

```
Total number of full neighbors: 1
```

```
OSPF process 100 VRF(default):
```

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
2.2.2.2	1	Full/DR	00:00:37	10.10.10.2	ce46/3	0

```
PE1#
```

```
PE1#sh ip vrf
```

```
VRF management, VRF ID: 1, FIB ID 1
```

```
MPLS DSCP Preserve Enabled (global)
```

```
Router ID: 10.12.96.29 (automatic)
```

```
Interfaces:
```

```
eth0
```

```
lo.management
```

```
!  
VRF vrf100, VRF ID: 2, FIB ID 2  
MPLS DSCP Preserve Enabled (global)  
  Router ID: 100.100.100.1 (automatic)  
Interfaces:  
  lo.vrf100  
  xe0.100  
!  
Total Number of configured IP VRF's: 2  
Total Number of all VRF's: 3
```

Name	Default RD
management	not set
vrf100	1.1.1.1:100

PE1#

```
PE1#show ip bgp summary  
BGP router identifier 100.100.100.1, local AS number 100  
BGP VRF vrf100 Route Distinguisher: 1.1.1.1:100  
BGP table version is 5  
1 BGP AS-PATH entries  
0 BGP community entries
```

Neighbor PfxRcd Desc	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
100.100.100.2 10	4	100	116	131	5	0	0	00:01:06	

Total number of neighbors 1

Total number of Established sessions 1
PE1#

```
PE1#show ip bgp vpnv4 all summary  
BGP router identifier 1.1.1.1, local AS number 100  
BGP table version is 3  
1 BGP AS-PATH entries  
0 BGP community entries
```

Neighbor PfxRcd Desc	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
3.3.3.3 1	4	100	139	141	2	0	0	00:00:28	

Total number of neighbors 1

Total number of Established sessions 1

```
BGP VRF vrf100 Route Distinguisher: 1.1.1.1:100  
BGP table version is 5
```


1 BGP AS-PATH entries
0 BGP community entries

Neighbor PfxRcd Desc	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/
100.100.100.2 10	4	100	116	131	5	0	0	00:01:12	

Total number of neighbors 1

Total number of Established sessions 1
PE1#

PE1#show interface counters rate mbps

Interface	Rx mbps	Rx pps	Tx mbps	Tx pps
ce46/3	0.00	0	10.36	9810
xe0	10.21	9969	0.00	0
xe0.100	10.25	10007	0.00	0

PE1#

PE1#show interface ce46/3 counters queue-stats

E - Egress, I - Ingress, Q-Size is in bytes

Queue/Class-map	Q-Size	Tx pkts	Tx bytes	Dropped pkts	Dropped bytes
q0	(E) 12499968 0	0	0	0	0
q1	(E) 12499968 0	0	0	0	0
q2	(E) 12499968 0	0	0	0	0
q3	(E) 12499968 7931421	872455900	0	0	0
q4	(E) 12499968 0	0	0	0	0
q5	(E) 12499968 0	0	0	0	0
q6	(E) 12499968 377	30275	0	0	0
q7	(E) 12499968 252	14180	0	0	0

PE1#

Once the end to end traffic is verified, capture the packet on egress interface of the ingress node. Below is the example packet capture.

100.100.100.2 → 200.200.200.2 IPv4 Unknown (253)															
68	21	5F	1F	52	21	5C	07	58	51	13	42	88	47	06	68
08	40	06	B8	09	40	45	60	00	6A	CB	85	00	00	FE	FD
96	7F	64	64	64	02	C8	C8	C8	02	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	7A	50	DE	BE
BB	F7	F9	31	20	D9	5F	8C	19	3E	FB	D4	91	B2	CA	9B

4 protocols in packet:

Ethernet	MPLS	MPLS	IPv4
----------	------	------	------

Below snapshot is the decoded output of the packet capture. Here we can see that EXP bit is 4 and preserved DSCP value is 24.

- **Frame 1: 128 bytes on wire (1024 bits)**
- **Ethernet II**
- **MultiProtocol Label Switching Header**
 - 0000 0110 0110 1000 0000 = MPLS Label: 26240 (0x06680)
 - 100. = MPLS Experimental Bits: 4
 - 0 = MPLS Bottom Of Label Stack: 0
 - 0100 0000 = MPLS TTL: 64
- **MultiProtocol Label Switching Header**
- **Internet Protocol Version 4**
 - 0100 = Version: 4
 - 0101 = Header Length: 20 bytes (5)
 - **Differentiated Services Field: 0x60 (DSCP: CS3, ECN: Not-ECT)**
 - 0110 00.. = Differentiated Services Codepoint: Class Selector 3 (24)
 -00 = Explicit Congestion Notification: Not ECN-Capable Transport (0)
 - Total Length: 106
 - Identification: 0xcb85 (52101)
 - 000. = Flags: 0x0
 - ...0 0000 0000 0000 = Fragment Offset: 0
 - Time to Live: 254
 - Protocol: Unknown (253)
 - Header Checksum: 0x967f
 - Header checksum status: Unverified
 - Source Address: 100.100.100.2
 - Destination Address: 200.200.200.2
 - Stream index: 0

```
PE1#show qos-profile type dscp-to-queue dscp_profile1
profile name: dscp_profile1
```

```

profile type: dscp-to-queue
profile attached to 1 instances
configured mapping:
  dscp 24 queue 3 dscp 32
Detailed mapping:

```

-----+-----				-----+-----				-
-----+-----				-----+-----				-
INPUT		OUTPUT		INPUT		OUTPUT		
INPUT		OUTPUT		INPUT		OUTPUT		
-----+-----				-----+-----				-
-----+-----				-----+-----				-
DSCP	TC	Color	remark DSCP	DSCP	TC	Color	remark DSCP	
DSCP	TC	Color	remark DSCP	DSCP	TC	Color	remark DSCP	
		(TC)				(TC)		
-----+-----				-----+-----				-
-----+-----				-----+-----				-
0	0	green	0 (0)	16	2	green	16 (2)	
32	4	green	32 (4)	48	6	green	48 (6)	
1	0	green	1 (0)	17	2	green	17 (2)	
33	4	green	33 (4)	49	6	green	49 (6)	
2	0	green	2 (0)	18	2	green	18 (2)	
34	4	green	34 (4)	50	6	green	50 (6)	
3	0	green	3 (0)	19	2	green	19 (2)	
35	4	green	35 (4)	51	6	green	51 (6)	
4	0	green	4 (0)	20	2	yellow	20 (2)	
36	4	yellow	36 (4)	52	6	green	52 (6)	
5	0	green	5 (0)	21	2	green	21 (2)	
37	4	green	37 (4)	53	6	green	53 (6)	
6	0	green	6 (0)	22	2	yellow	22 (2)	
38	4	yellow	38 (4)	54	6	green	54 (6)	
7	0	green	7 (0)	23	2	green	23 (2)	
39	4	green	39 (4)	55	6	green	55 (6)	
8	1	green	8 (1)	24	3	green	32 (4)	
40	5	green	40 (5)	56	7	green	56 (7)	
9	1	green	9 (1)	25	3	green	25 (3)	
41	5	green	41 (5)	57	7	green	57 (7)	
10	1	green	10 (1)	26	3	green	26 (3)	
42	5	green	42 (5)	58	7	green	58 (7)	
11	1	green	11 (1)	27	3	green	27 (3)	
43	5	green	43 (5)	59	7	green	59 (7)	
12	1	yellow	12 (1)	28	3	yellow	28 (3)	
44	5	green	44 (5)	60	7	green	60 (7)	
13	1	green	13 (1)	29	3	green	29 (3)	
45	5	green	45 (5)	61	7	green	61 (7)	
14	1	yellow	14 (1)	30	3	yellow	30 (3)	
46	5	green	46 (5)	62	7	green	62 (7)	
15	1	green	15 (1)	31	3	green	31 (3)	
47	5	green	47 (5)	63	7	green	63 (7)	

PE1#

```

PE1#show qos-profile interface ce46/3
profile name: default
profile type: dscp-to-queue (Ingress)
mapping:

```

-----+-----				-----+-----				-
-----+-----				-----+-----				-

INPUT				OUTPUT				INPUT				OUTPUT			
INPUT				OUTPUT				INPUT				OUTPUT			
-----+-----				-----+-----				-----+-----				-----+-----			
-----+-----				-----+-----				-----+-----				-----+-----			
DSCP	TC	Color	remark DSCP	DSCP	TC	Color	remark DSCP	DSCP	TC	Color	remark DSCP	DSCP	TC	Color	remark DSCP
DSCP	TC	Color	remark DSCP	DSCP	TC	Color	remark DSCP	DSCP	TC	Color	remark DSCP	DSCP	TC	Color	remark DSCP
			(TC)				(TC)				(TC)				(TC)
-----+-----				-----+-----				-----+-----				-----+-----			
0	0	green	0 (0)	16	2	green	16 (2)	48	6	green	48 (6)	32	4	green	32 (4)
1	0	green	1 (0)	17	2	green	17 (2)	49	6	green	49 (6)	33	4	green	33 (4)
2	0	green	2 (0)	18	2	green	18 (2)	50	6	green	50 (6)	34	4	green	34 (4)
3	0	green	3 (0)	19	2	green	19 (2)	51	6	green	51 (6)	35	4	green	35 (4)
4	0	green	4 (0)	20	2	yellow	20 (2)	52	6	green	52 (6)	36	4	yellow	36 (4)
5	0	green	5 (0)	21	2	green	21 (2)	53	6	green	53 (6)	37	4	green	37 (4)
6	0	green	6 (0)	22	2	yellow	22 (2)	54	6	green	54 (6)	38	4	yellow	38 (4)
7	0	green	7 (0)	23	2	green	23 (2)	55	6	green	55 (6)	39	4	green	39 (4)
8	1	green	8 (1)	24	3	green	24 (3)	56	7	green	56 (7)	40	5	green	40 (5)
9	1	green	9 (1)	25	3	green	25 (3)	57	7	green	57 (7)	41	5	green	41 (5)
10	1	green	10 (1)	26	3	green	26 (3)	58	7	green	58 (7)	42	5	green	42 (5)
11	1	green	11 (1)	27	3	green	27 (3)	59	7	green	59 (7)	43	5	green	43 (5)
12	1	yellow	12 (1)	28	3	yellow	28 (3)	60	7	green	60 (7)	44	5	green	44 (5)
13	1	green	13 (1)	29	3	green	29 (3)	61	7	green	61 (7)	45	5	green	45 (5)
14	1	yellow	14 (1)	30	3	yellow	30 (3)	62	7	green	62 (7)	46	5	green	46 (5)
15	1	green	15 (1)	31	3	green	31 (3)	63	7	green	63 (7)	47	5	green	47 (5)

profile name: default
profile type: dscp-to-dscp (Egress)
Status: Inactive
mapping:

INPUT				OUTPUT				INPUT				OUTPUT			
INPUT				OUTPUT				INPUT				OUTPUT			
-----+-----				-----+-----				-----+-----				-----+-----			
-----+-----				-----+-----				-----+-----				-----+-----			
Remark DSCP	Color	Out DSCP	Remark DSCP	Remark DSCP	Color	Out DSCP	Remark DSCP	Remark DSCP	Color	Out DSCP	Remark DSCP	Remark DSCP	Color	Out DSCP	Remark DSCP
Remark DSCP	Color	Out DSCP	Remark DSCP	Remark DSCP	Color	Out DSCP	Remark DSCP	Remark DSCP	Color	Out DSCP	Remark DSCP	Remark DSCP	Color	Out DSCP	Remark DSCP
(TC)	(TC)		(TC)	(TC)			(TC)	(TC)			(TC)	(TC)			(TC)
0 (0)	red	green	0	0 (0)	yellow	0	0	0 (0)	yellow	0	0	0 (0)	yellow	0	0

1 (0)	red	green	1	1	1 (0)	yellow	1	1
(0)								
2 (0)	red	green	2	2	2 (0)	yellow	2	2
(0)								
3 (0)	red	green	3	3	3 (0)	yellow	3	3
(0)								
4 (0)	red	green	4	4	4 (0)	yellow	4	4
(0)								
5 (0)	red	green	5	5	5 (0)	yellow	5	5
(0)								
6 (0)	red	green	6	6	6 (0)	yellow	6	6
(0)								
7 (0)	red	green	7	7	7 (0)	yellow	7	7
(0)								
8 (1)	red	green	8	8	8 (1)	yellow	8	8
(1)								
9 (1)	red	green	9	9	9 (1)	yellow	9	9
(1)								
10 (1)	red	green	14	10	10 (1)	yellow	12	10
(1)								
11 (1)	red	green	11	11	11 (1)	yellow	11	11
(1)								
12 (1)	red	green	14	12	12 (1)	yellow	12	12
(1)								
13 (1)	red	green	13	13	13 (1)	yellow	13	13
(1)								
14 (1)	red	green	14	14	14 (1)	yellow	14	14
(1)								
15 (1)	red	green	15	15	15 (1)	yellow	15	15
(1)								
16 (2)	red	green	16	16	16 (2)	yellow	16	16
(2)								
17 (2)	red	green	17	17	17 (2)	yellow	17	17
(2)								
18 (2)	red	green	22	18	18 (2)	yellow	20	18
(2)								
19 (2)	red	green	19	19	19 (2)	yellow	19	19
(2)								
20 (2)	red	green	22	20	20 (2)	yellow	20	20
(2)								
21 (2)	red	green	21	21	21 (2)	yellow	21	21
(2)								
22 (2)	red	green	22	22	22 (2)	yellow	22	22
(2)								
23 (2)	red	green	23	23	23 (2)	yellow	23	23
(2)								
24 (3)	red	green	24	24	24 (3)	yellow	24	24
(3)								
25 (3)	red	green	25	25	25 (3)	yellow	25	25
(3)								
26 (3)	red	green	30	26	26 (3)	yellow	28	26
(3)								
27 (3)	red	green	27	27	27 (3)	yellow	27	27
(3)								
28 (3)	red	green	30	28	28 (3)	yellow	28	28
(3)								
29 (3)	red	green	29	29	29 (3)	yellow	29	29
(3)								
30 (3)	red	green	30	30	30 (3)	yellow	30	30
(3)								
31 (3)	red	green	31	31	31 (3)	yellow	31	31
(3)								

32 (4)		green	32	32 32 (4)	yellow	32 32
(4)	red					
33 (4)		green	33	33 33 (4)	yellow	33 33
(4)	red					
34 (4)		green	38	34 34 (4)	yellow	36 34
(4)	red					
35 (4)		green	35	35 35 (4)	yellow	35 35
(4)	red					
36 (4)		green	38	36 36 (4)	yellow	36 36
(4)	red					
37 (4)		green	37	37 37 (4)	yellow	37 37
(4)	red					
38 (4)		green	38	38 38 (4)	yellow	38 38
(4)	red					
39 (4)		green	39	39 39 (4)	yellow	39 39
(4)	red					
40 (5)		green	40	40 40 (5)	yellow	40 40
(5)	red					
41 (5)		green	41	41 41 (5)	yellow	41 41
(5)	red					
42 (5)		green	42	42 42 (5)	yellow	42 42
(5)	red					
43 (5)		green	43	43 43 (5)	yellow	43 43
(5)	red					
44 (5)		green	44	44 44 (5)	yellow	44 44
(5)	red					
45 (5)		green	45	45 45 (5)	yellow	45 45
(5)	red					
46 (5)		green	46	46 46 (5)	yellow	46 46
(5)	red					
47 (5)		green	47	47 47 (5)	yellow	47 47
(5)	red					
48 (6)		green	48	48 48 (6)	yellow	48 48
(6)	red					
49 (6)		green	49	49 49 (6)	yellow	49 49
(6)	red					
50 (6)		green	50	50 50 (6)	yellow	50 50
(6)	red					
51 (6)		green	51	51 51 (6)	yellow	51 51
(6)	red					
52 (6)		green	52	52 52 (6)	yellow	52 52
(6)	red					
53 (6)		green	53	53 53 (6)	yellow	53 53
(6)	red					
54 (6)		green	54	54 54 (6)	yellow	54 54
(6)	red					
55 (6)		green	55	55 55 (6)	yellow	55 55
(6)	red					
56 (7)		green	56	56 56 (7)	yellow	56 56
(7)	red					
57 (7)		green	57	57 57 (7)	yellow	57 57
(7)	red					
58 (7)		green	58	58 58 (7)	yellow	58 58
(7)	red					
59 (7)		green	59	59 59 (7)	yellow	59 59
(7)	red					
60 (7)		green	60	60 60 (7)	yellow	60 60
(7)	red					
61 (7)		green	61	61 61 (7)	yellow	61 61
(7)	red					
62 (7)		green	62	62 62 (7)	yellow	62 62
(7)	red					

```

        63 (7)      red    green      63      63 | 63 (7)      yellow      63 | 63
(7)
PE1#

```

CLI Commands

The Per-VRF DSCP preserve introduces the following configuration commands.

mpls lsp-encap-dscp-preserve

Use this command to preserve DSCP for IP packets encapsulated into MPLS headers when DSCP is remarked on access interface. By default, DSCP is not preserved for IP packets encapsulated into MPLS headers.

Use the `no` parameter with this to unconfigure DSCP preserve.

Note: In Qumran1 devices, DSCP preserve feature is not supported when the transport is Segment Routing.

Command Syntax

```

mpls lsp-encap-dscp-preserve (enable | disable)
no mpls lsp-encap-dscp-preserve

```

Parameters

<code>enable</code>	Enable the configuration.
<code>disable</code>	Disable the configuration

Default

disable

Command Mode

VRF mode

Applicability

Introduced in OcNOS version 6.5.3.

Example

Example for enabling or disabling DSCP preserve based on requirement per-vrf level:

```

#configure terminal
(config)#ip vrf vrf100
(config-vrf)#mpls lsp-encap-dscp-preserve (enable | disable)
(config-vrf)#commit
(config-vrf)#exit

```

Example for unconfiguring DSCP preserve:

```

#configure terminal
(config)#ip vrf vrf100
(config-vrf)#no mpls lsp-encap-dscp-preserve
(config-vrf)#commit
(config-vrf)#exit

```

mpls 6pe lsp-encap-dscp-preserve

Use this command to preserve DSCP for IP packets encapsulated into MPLS headers when DSCP is remarked on access interface. By default, DSCP is not preserved for IP packets encapsulated into MPLS headers.

Use the `no` parameter with this to unconfigure DSCP preserve.

Note: In Qumran1 devices, DSCP preserve feature is not supported when the transport is Segment Routing.

Command Syntax

```
mpls 6pe lsp-encap-dscp-preserve (enable | disable)
no mpls 6pe lsp-encap-dscp-preserve
```

Parameters

<code>enable</code>	Enable the configuration.
<code>disable</code>	Disable the configuration

Default

disable

Command Mode

Config mode

Applicability

Introduced in OcNOS version 6.5.3.

Example

Example for enabling or disabling DSCP preserve for 6PE services:

```
#configure terminal
(config)#mpls 6pe lsp-encap-dscp-preserve (enable | disable)
(config)#commit
(config)#exit
```

Example for unconfiguring DSCP preserve for 6PE services:

```
#configure terminal
(config)#no mpls 6pe lsp-encap-dscp-preserve
(config)#commit
(config)#exit
```

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
DSCP	Differentiated Services Code Point (DSCP) is a 6-bit value used to classify the priority of Layer-3 packets upon entry into a network. DSCP values range from 0 to 63, 63 being the highest priority, 0 being best-effort traffic.
IS-IS	Intermediate System to Intermediate System (IS-IS) An Interior Gateway Protocol (IGP) that floods link state information throughout a network of routers. Each IS-IS router independently builds a database of the network's topology, aggregating the flooded network information. A Routing Information Base (RIB) is calculated from the database by constructing a shortest path tree (SPT).
MPLS	Multi-Protocol Label Switching (MPLS) A method for forwarding packets through a network. MPLS operates between the traditional definitions of Layer 2 (L2) and Layer 3 (L3).
QoS	Quality of Service (QoS) The ability to guarantee the delivery, control the bandwidth, set priorities for specific network traffic, and provide an appropriate level of security. QoS provides a level of predictability and control beyond the best effort delivery that a device provides by default.

Label Distribution Protocol Configuration

CHAPTER 1 LDP Configuration

This chapter contains LDP (Label Distribution Protocol) configuration examples.

Label Distribution Protocol Overview

The Label Distribution Protocol (LDP) is a routing protocol used in MPLS technology. The LDP daemon (`ldpd`) uses NSM services to obtain routing information. Routers send Hello packets to establish Hello Adjacencies with other nearby routers. This opens the way for sessions between routers to be established during which routers exchange labels in preparation for forwarding packets.

LDP generates labels for and exchanges labels between peer routers. It works in with other routing protocols (RIP, OSPF and BGP) to create label-switched paths (LSP) used when forwarding packets. A label-switched path is the path taken by all packets that belong to the Forwarding Equivalence Class (FEC) corresponding to that LSP. This is analogous to establishing a virtual circuit in ATM (Asynchronous Transfer Mechanism). In this way, OcNOS LDP assigns labels to every destination address and destination prefix provided by OcNOS. The LDP interface to the MPLS forwarder adds labels to, and deletes labels from, the forwarding tables.

LDP Adjacencies

LDP defines a mechanism for discovering adjacent, LDP capable Label Switching Routers (LSR) that participate in label switching (adjacencies). Whenever a new router comes up it sends out a hello packet to a specified, multicast address announcing itself to the network. Every router directly connected to the network receives the packet. Receipt of a hello packet from another LSR creates a *Hello Adjacency* with that LSR. To create a Hello Adjacency with an LSR that cannot send/receive multicast packets, LDP allows a router to be manually configured to send unicast Hello packets to non-multicast LSRs. This non-multicast LSR is a *targeted peer*. Adjacencies are maintained by sending out periodic Hello packets to the multicast group and to all targeted peers. Hello packets are sent using UDP.

LDP Session

LDP capable LSRs establish a session before exchanging label information. All the session messages are sent using TCP to ensure reliable delivery. After the LSRs establish a session and negotiate options, a given pair of routers may exchange label information. The labels exchanged over a session are valid only during the lifetime of the session and routers release them when session is closed.

Forwarding Equivalence Class

A Forwarding Equivalence Class (FEC) section defines a set of packets that are forwarded on the same path by the MPLS network. Two common methods to define FEC are by advertising the IPv4 routes using:

- **Host Address** The LSR uses the address of the destination host to create this FEC. This means that all the packets going to this destination will take the same LSP.
- **Prefix** The LSR uses destination prefix to create this FEC. This means that all the packets take the LSP corresponding to the longest matching prefix.

Label Generation

An LDP Label is a 20-bit number the LSR uses to forward a packet to its destination. When an LSR creates a new FEC, the router generates new labels and distributes them to its peers. A router keeps both incoming and outgoing labels in its database.

Label Distribution Modes

The OcNOS LDP implementation supports two label distribution modes:

- **Downstream Unsolicited** In this mode, next hop LSRs distribute labels to peers without waiting for a label request.
- **Downstream on Demand** In this mode, a LSR distributes a label to a peer only if there is a pending label request from the peer.

Label Retention Mode

The OcNOS LDP implementation supports two label retention modes:

- **Liberal Retention Mode** In this mode, the LSR retains all labels received from all sources. This mode helps in fast LSP setup in case of a change in next hop.
- **Conservative Retention Mode** In this mode, the LSR retains only those labels received from peers that are the next hop for a given FEC. This mode is used by LSRs that have a constraint on the number of labels that it can retain at any given time.

LSP Control

LSPs can be set up in the following two ways:

- **Ordered Control** In this mode, an LSR distributes a label for a FEC to its peer only if it has a corresponding label from its next hop or it is the egress node.
- **Independent Control** In this mode, an LSR may distribute a label to its peers without waiting for a corresponding label from its next hop.

Loop Detection

Loop detection can be enabled to detect routing loops in LSPs. There are two methods supported for the loop detection mechanism:

- **Hop Count** During setup of an LSP, the LSP passes hop count with the LSP setup messages. This hop count is incremented by each node router participating in LSP establishment. If the hop count exceeds the maximum configured value, the LSP setup process is stopped and a notification message is passed back to the message originator.
- **Path Vector** A path vector contains a list of LSR identifiers. This is passed as a part of LSP setup messages. Each LSR participating in the LSP establishment adds its own LSR identifier to the path vector. If an LSR finds its own identifier in the path vector, it drops the message and sends a message back to the originator.

The use of these messages ensures that a loop is detected while establishing a label switched path and before any data is passed over that LSP.

Configure LDP

The `enable-ldp ipv4` command is used to enable LDP for IPv4 on a specified interface, as follows:

- `enable-ldp ipv4` enables only IPv4 on the interface

For the examples covered in this section, the command `enable-ldp ipv4` is used.

Enable Label Switching

Running LDP on a system requires the following tasks:

1. Enabling label-switching on the interface on NSM.
2. Enabling LDP on an interface in the LDP daemon.
3. Running an IGP (Internal Gateway Protocol), for example, OSPF, to distribute reachability information within the MPLS cloud.
4. Configuring the transport address.

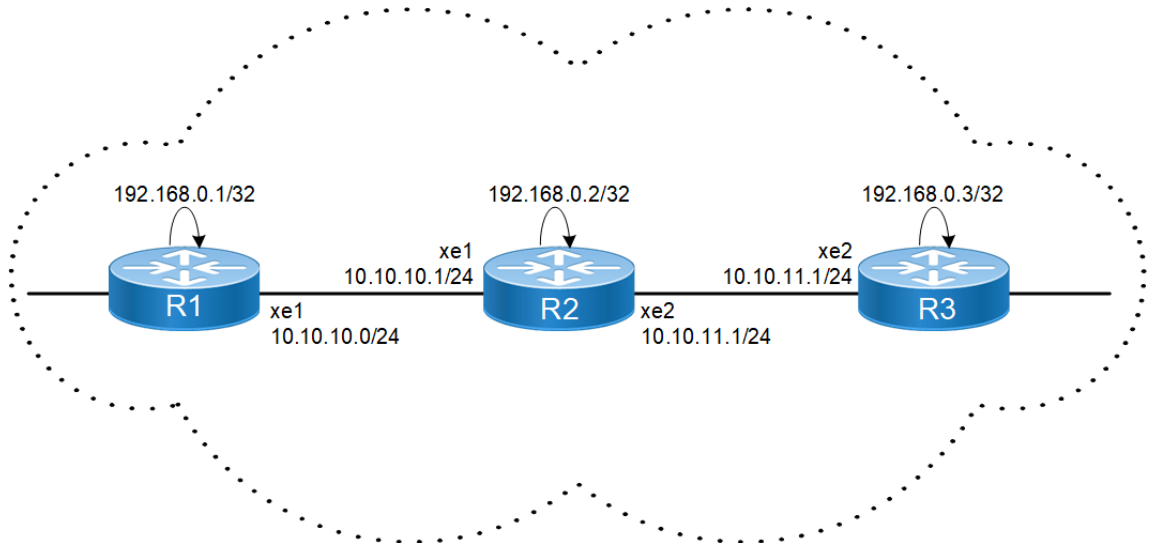


Figure 1-32: Basic LDP Topology

R1 - NSM

#configure terminal	Enter configure mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.10.10.1/24	Assign IP address to interface.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 192.168.0.1/32 secondary	Set the IP address of the loopback interface to 192.168.0.1/32.
(config-if)#commit	Commit the transaction.

R1 - LDP

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 192.168.0.1	Set the router ID to IP address 192.168.0.1.

(config-router)#transport-address ipv4 192.168.0.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#targeted-peer ipv4 192.168.0.3	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe1.
(config-if)#commit	Commit the transaction.

R1 - OSPF

(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.10.10.0/24 area 0 (config-router)#network 192.168.0.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

R2 - NSM

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 192.168.0.2/32 secondary	Set the IP address of the loopback interface to 192.168.0.2/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.10.10.2/24	Assign IP address to interface
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#ip address 10.10.11.1/24	Assign IP address to interface.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#commit	Commit the transaction.

R2 - LDP

(config)#router ldp	Enter Router mode.
(config-router)#router-id 192.168.0.2	Set the router ID to IP address 192.168.0.2.

(config-router)#transport-address ipv4 192.168.0.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#exit	Exit Router mode and return to Configure mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (xe1) .
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (xe .
(config-if)#commit	Commit the transaction.

R2 - OSPF

(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.10.10.0/24 area 0 (config-router)#network 10.10.11.0/24 area 0 (config-router)#network 192.168.0.2/32 area 0	Define the interfaces on which OSPF runs and associate the area ID (0) with them.
(config-router)#commit	Commit the transaction.

R3 - NSM

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 192.168.0.3/32 secondary	Set the IP address of the loopback interface to 192.168.0.3/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#ip address 10.10.11.1/24	Set the IP address of the interface to 10.10.11.1/24.
(config-if)#label-switching	Enable label switching on interface xe2 .
(config-if)#commit	Commit the transaction.

R3 - LDP

(config)#router ldp	Enter Router mode.
(config-router)#router-id 192.168.0.3	Set the router ID for IP address 192.168.0.3 .
(config-router)#transport-address ipv4 192.168.0.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.

(config-router)#targeted-peer ipv4 192.168.0.1	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe2 .
(config-if)#commit	Commit the transaction.

R3 - OSPF

(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.10.11.0/24 area 0 (config-router)#network 192.168.0.3/32 area 0	Define the interfaces on which OSPF runs and associate the area ID (0) with them.
(config-router)#commit	Commit the transaction.

Validation

PE1

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
192.168.0.2	xe1	Passive	OPERATIONAL	30	00:18:59
192.168.0.3	xe1	Passive	OPERATIONAL	30	00:02:07

PE1#show ldp targeted-peer count

Num Targeted Peers: 1 [UP: 1]

PE1#show ldp session count

Multicast Peers : 2 [UP: 1]
 Targeted Peers : 1 [UP: 0]
 Total Sessions : 2 [UP: 1]

PE1#show ldp routes

Prefix Addr	Nexthop Addr	Intf	Owner
10.10.10.0/24	0.0.0.0	xe1	
10.10.11.0/24	10.10.10.2	xe1	
192.168.0.1/32	0.0.0.0	lo	
192.168.0.2/32	10.10.10.2	xe1	
192.168.0.3/32	10.10.10.2	xe1	

PE1#show ldp fec-ipv4 count

Num. IPv4 FEC(s): 5

P

P#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
192.168.0.1	xe1	Active	OPERATIONAL	30	00:23:52
192.168.0.3	xe2	Passive	OPERATIONAL	30	00:23:49

```
P#show ldp session count
Multicast Peers : 3    [UP: 2]
Targeted Peers  : 0    [UP: 0]
Total Sessions  : 2    [UP: 2]
```

```
P#show ldp routes
Prefix Addr    Nexthop Addr  Intf  Owner
10.10.10.0/24  0.0.0.0      xe1   connected
10.10.11.0/24  0.0.0.0      xe2   connected
192.168.0.1/32 10.10.10.1   xe1   ospf
192.168.0.2/32 0.0.0.0      lo    connected
192.168.0.3/32 10.10.11.2   xe2   ospf
```

PE2

```
PE2#show ldp session
Peer IP Address  IF Name  My Role  State          KeepAlive  UpTime
192.168.0.2      xe2      Active   OPERATIONAL    30         00:27:47
192.168.0.1      xe2      Active   OPERATIONAL    30         00:10:58
```

```
PE2#show ldp session count
Multicast Peers : 2    [UP: 1] Targeted Peers : 1    [UP: 1]
Total Sessions  : 2    [UP: 2]
```

```
OcNOS#show ldp targeted-peer count
Num Targeted Peers: 1    [UP: 1]
```

```
OcNOS#show ldp routes
Prefix Addr    Nexthop Addr  Intf  Owner
10.10.10.0/24  10.10.11.1   xe2   ospf
10.10.11.0/24  0.0.0.0      xe2   connected
192.168.0.1/32 10.10.11.1   xe17  ospf
192.168.0.2/32 10.10.11.1   xe2   ospf
192.168.0.3/32 0.0.0.0      lo    connected
```

```
PE2#show ldp fec
fec fec-ipv4
```

```
PE2#show ldp fec-ipv4 count
```

```
-----
Num. IPv4 FEC(s): 5
-----
```

LDP MD5 Authentication

LDP MD5 configuration enables LDP MD5 password authentication on a per-peer basis.

Direct LDP Session

In this example, MD5 authentication is configured for a direct LDP session.

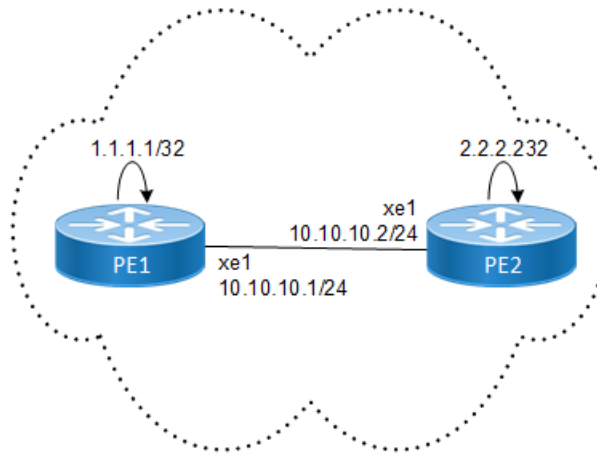


Figure 1-33: Topology for Direct Session MD5

R1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode.
(config)#router-id 1.1.1.1	Configure the router id.
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#neighbor 10.10.10.2 auth md5 password 0 pwd1	Configure the MD5 authentication and password, pwd1, for the neighbor, 10.10.10.2.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.10.10.1/24	Set the IP address of the interface to 10.10.10.1/24..
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config-if)#commit	Commit the transaction.

R2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode.
(config)#router-id 2.2.2.2	Configure the router id.
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.

(config-router)#neighbor 10.10.10.1 auth md5 password 0 pwd1	Configure the MD5 authentication and password, pwd1, for the neighbor, 10.10.10.1.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.10.10.2/24	Set the IP address of the interface to 10.10.10.2/24.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config-if)#commit	Commit the transaction.

Validation

PE1

```
PE1#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe1	Passive	OPERATIONAL	30	00:14:53

```
PE1#show ldp session count
```

```
-----
Multicast Peers      : 1          [UP: 1]
Targeted Peers      : 1          [UP: 1]
Total Sessions      : 1          [UP: 1]
-----
```

PE2

```
PE2#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:15:05

```
PE2#sh ldp session count
```

```
-----
Multicast Peers      : 1          [UP: 1]
Targeted Peers      : 1          [UP: 1]
Total Sessions      : 1          [UP: 1]
-----
```

Configure LDP MD5 for Targeted LDP Session

In this example, MD5 authentication is configured for the targeted LDP session established between R1 and R3.

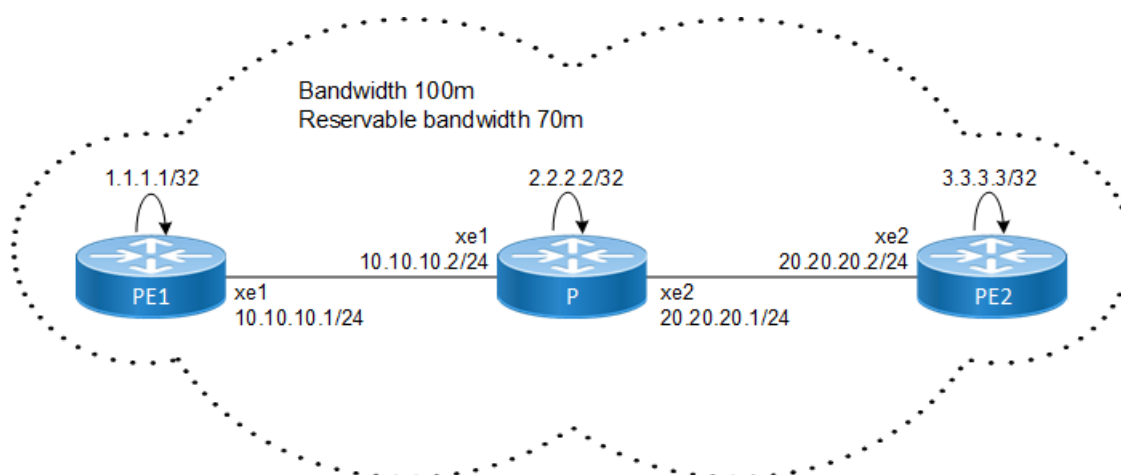


Figure 1-34: Topology for Targeted Session MD5

PE1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode.
(config-router)#neighbor 10.10.10.2 auth md5 password 0 pwd1	Configure the MD5 authentication and password, pwd1, for the neighbor, 10.10.10.2.
(config-router)#targeted-peer ipv4 3.3.3.3	Configure the targeted peer IP address (R3 loopback address).
(config-router-targeted-peer)#exit	Exit targeted peer mode.
(config-router)#neighbor 3.3.3.3 auth md5 password 0 pwd2	Configure the MD5 authentication and password, pwd2, for the targeted peer, 3.3.3.3.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface lo	Specify the loopback interface (lo) to be configured.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/ 32.
(config-if)#commit	Commit the transaction.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.10.10.1/24	Set the IP address of the interface to 10.10.10.1/24.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.

P

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode to enable LDP.
(config)#router-id 2.2.2.2	Configure the router ID.
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.

(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe2.
(config-if)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode.
(config-router)#router-id 3.3.3.3	Configure the router-id
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure the targeted peer IP address (R1 loopback address).
(config-router-targeted-peer)#exit	Exit targeted peer mode.
(config-router)#neighbor 1.1.1.1 auth md5 password 0 pwd2	Configure the MD5 authentication and password, pwd2, for the targeted peer, 1.1.1.1.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be config.
(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe2.
(config-if)#commit	Commit the transaction.

Removing MD5 Authentication for LDP Session

This example shows removing the MD5 authentication configuration from an LDP session.

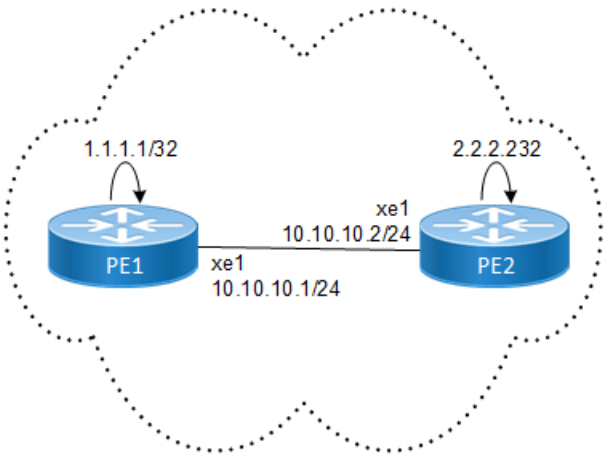


Figure 1-35: LDP Session Topology

PE1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode.
(config-router)#no neighbor 10.10.10.2 auth md5 password	Remove MD5 authentication for the neighbor, 10.10.10.2.
(config-router)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode.
(config-router)#no neighbor 10.10.10.1 auth md5 password	Remove MD5 authentication for the neighbor, 10.10.10.1.
(config-router)#commit	Commit the transaction.
(config)#interface lo	Specify the loopback (lo) interface to be config
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32
(config-if)#exit	Exit lo interface
(config-if)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.10.10.2/24	Set the IP address of the interface to 10.10.10.2/24
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config-if)#commit	Commit the transaction.

Validation for LDP Session Count

This example shows the number of configured LDP basic neighbors and targeted neighbors count.

```
#show ldp session count
-----
Basic sessions      : 100          [UP: 100]
```

```

Targeted sessions   : 500           [UP: 500]
Total Sessions      : 600           [UP: 600]
-----

```

```

#show ldp targeted-peer count
-----

```

```

Num Targeted Peers: 500           [UP: 500]
-----

```

Validation for FTN, SWAP, and POP Entries

This example shows forwarding table entries, SWAP entries and POP entries for IPV4 and IPV6 prefixes.

```

#show mpls forwarding-table count
-----

```

```

Num FTNs           : 300000         [UP: 3, INSTALLED: 300000]
Primary FTNs       : 300000         [UP: 3, INSTALLED: 300000]
Secondary FTNs    : 0               [UP: 0, INSTALLED: 0]
-----

```

```

Num IPV6 FTNs      : 300000         [UP: 300000, INSTALLED: 300000]
Primary IPV6 FTNs  : 300000         [UP: 300000, INSTALLED: 300000]
Secondary IPV6 FTNs : 0             [UP: 0, INSTALLED: 0]
-----

```

```

#show mpls ilm-table count
-----

```

```

Num ILMs           : 300000         [UP: 0, INSTALL: 300000]
Swap Entries       : 300000         [UP: 0, INSTALL: 300000]
Pop Entries        : 0              [UP: 0, INSTALL: 0]
VC Pop Entries     : 0              [UP: 0]
-----

```

MPLS LDP PING and TRACEROUTE

This example shows MPLS ping and trace route for LDP

```

#show ip ospf neighbor

```

```

Total number of full neighbors: 1

```

```

OSPF process 0 VRF(default):

```

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
2.2.2.2 0	1	Full/DR	00:00:33	10.10.10.2	xe1

```

#show ldp session

```

Peer IP Address	IF Name	My Role	State	KeepAlive
2.2.2.2	xe1	Passive	OPERATIONAL	30

```

#show mpls forwarding-table

```

```

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

```

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	1	-	-	LSP_DEFAULT	3
xel	No	10.10.10.2					

```
#ping mpls ldp 2.2.2.2/32 detail
Sending 5 MPLS Echos to 2.2.2.2, timeout is 5 seconds
Codes:
```

```
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
```

```
Type 'Ctrl+C' to abort
! seq_num = 1 2.2.2.2 1.73 ms
! seq_num = 2 2.2.2.2 1.46 ms
! seq_num = 3 2.2.2.2 0.64 ms
! seq_num = 4 2.2.2.20.65 ms
! seq_num = 5 2.2.2.20.62 ms
Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.62/1.18/1.73
```

```
#trace mpls ldp 2.2.2.2/32 detail
Tracing MPLS Label Switched Path to 2.2.2.2, timeout is 5 seconds
Codes:
```

```
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
```

```
Type 'Ctrl+C' to abort
0 10.10.10.2 [Labels: 0]
! 1 2.2.2.2 0.69 ms
```

```
#ping mpls ldp 2.2.2.2/32 detail interval 5000 rep
reply-mode repeat
#ping mpls ldp 2.2.2.2/32 detail interval 5000 repeat 50
Sending 50 MPLS Echos to 2.2.2.2, timeout is 5 seconds
Codes:
```

```
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
```



```
'P' - Protocol Error, 'X' - Unknown code,  
'Z' - Reverse FEC Validation Failed  
Type 'Ctrl+C' to abort  
! seq_num = 1 2.2.2.2 0.70 ms  
! seq_num = 2 2.2.2.2 0.73 ms  
! seq_num = 3 2.2.2.2 0.71 ms  
Success Rate is 100.00 percent (3/3)  
round-trip min/avg/max = 0.70/0.71/0.73
```

LDP Session Protection

LDP Session Protection is an optimization feature. It is used when directly connected LDP peer sessions (via multicast) become unavailable but still have IP reachability over a different path. LDP bindings are kept in the LIB to save time from full synchronization when the direct connections comes back up.

There are two types of LDP connections:

- Direct LDP Session - directly connected LSR, one hop away.
- Targeted LDP Session - not directly connected LSR, multiple hops away.

By default if the directly connected LDP session loses connectivity to its peer, all bindings are flushed from the LIB. When interfaces come up and LDP sessions are re-established, LDP has to synchronize its label bindings.

Enable session protection for indirect link failures to protect the labels until the session is active when multicast adjacency gets deleted. When multicast and TLDP connection exists between the same peer, the interface down notification is received only on the router with the link failure but not in the peer. When the interface goes down the multicast adjacency and the labels get deleted without notifying the peer device. When the interface comes up before the adjacency hold timer expires in the peer node, multicast adjacency is added and advertises the labels to the peer but does not receive any labels from the peer as there is no change in the adjacency.

LDP Session Protection is an optimization, when enabled, will not flush the LIB when direct LDP sessions go down. As long as there exists another path to the LDP Peer, it will maintain the LIB synchronized using Targeted LDP Session. IGP will cause a reroute, but the label bindings will still be present from the old peer. When interfaces come back up, LDP will not need to synchronize since it maintains the state using the targeted sessions.

1. Running LDP Session Protection on a system requires the following tasks:
2. Enabling label-switching on the interface on NSM.
3. Enabling LDP on an interface in the LDP daemon.
4. Running an IGP (Internal Gateway Protocol), for example, OSPF, to distribute reachability information within the MPLS cloud.
5. Configuring the transport address.
6. Configuring LDP Session Protection.

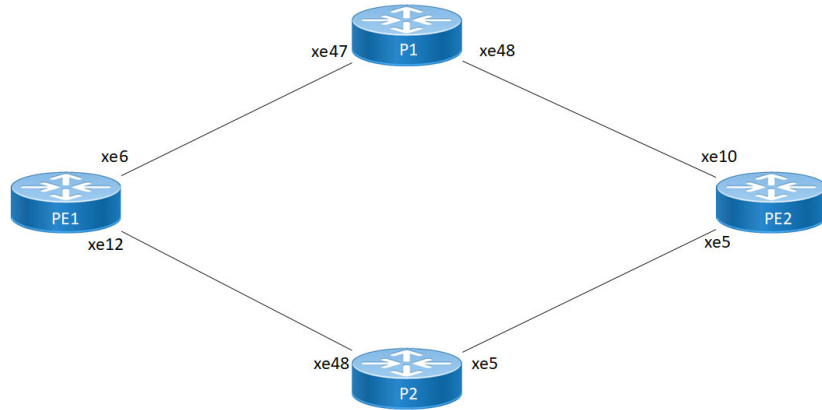


Figure 1-36: Basic LDP Topology

PE1 - NSM

#configure terminal	Enter configure mode.
(config)#interface xe6	Specify the interface (xe6) to be configured.
(config-if)#ip address 10.10.10.1/24	Configure IPv4 address for xe6
(config-if)#label-switching	Enable label switching on interface xe6.
(config)#interface xe12	Specify the interface (xe12) to be configured.
(config-if)#ip address 30.30.30.1/24	Configure IPv4 address for xe12
(config-if)#label-switching	Enable label switching on interface xe12.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 1.1.1.1/32	Set the IP address of the loopback interface to 1.1.1.1/32.
(config-if)#commit	Commit the transaction.

PE1 - LDP

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe6	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe6.
(config)#interface xe12	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe12.
(config-if)#commit	Commit the transaction.

PE1 - OSPF

(config)#router ospf 1	Configure the routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 1.1.1.1	Configure Router ID
(config-router)#network 1.1.1.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.10.10.1/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 30.30.30.1/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

P1 - NSM

#configure terminal	Enter configure mode.
(config)#interface xe47	Specify the interface (xe47) to be configured.
(config-if)#ip address 10.10.10.2/24	Configure IPv4 address for xe47
(config-if)#label-switching	Enable label switching on interface xe47.
(config)#interface xe48	Specify the interface (xe48) to be configured.
(config-if)#ip address 20.20.20.1/24	Configure IPv4 address for xe48
(config-if)#label-switching	Enable label switching on interface xe48.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if)#commit	Commit the transaction.

P1 - LDP

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe47	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe47.
(config)#interface xe48	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe48.
(config-if)#commit	Commit the transaction.

P1 - OSPF

(config)#router ospf 1	Configure the routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 2.2.2.2	Configure Router ID
(config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.10.10.2/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 20.20.20.1/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

P2 - NSM

#configure terminal	Enter configure mode.
(config)#interface xe48	Specify the interface (xe48) to be configured.
(config-if)#ip address 30.30.30.2/24	Configure IPv4 address for xe48
(config-if)#label-switching	Enable label switching on interface xe48.
(config)#interface xe5	Specify the interface (xe5) to be configured.
(config-if)#ip address 40.40.40.1/24	Configure IPv4 address for xe5
(config-if)#label-switching	Enable label switching on interface xe5.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 4.4.4.4/32 secondary	Set the IP address of the loopback interface to 4.4.4.4/32.
(config-if)#commit	Commit the transaction.

P2 - LDP

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 4.4.4.4	Set the router ID to IP address 4.4.4.4
(config-router)#transport-address ipv4 4.4.4.4	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe48	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe48.
(config)#interface xe5	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe5.
(config-if)#commit	Commit the transaction.

P2 - OSPF

(config)#router ospf 1	Configure the routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 4.4.4.4	Configure Router ID
(config-router)#network 4.4.4.4/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 20.20.20.2/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 30.30.30.1/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

PE2 - NSM

#configure terminal	Enter configure mode.
(config)#interface xe10	Specify the interface (xe10) to be configured.
(config-if)#ip address 20.20.20.2/24	Configure IPv4 address for xe10
(config-if)#label-switching	Enable label switching on interface xe10.
(config)#interface xe5	Specify the interface (xe5) to be configured.
(config-if)#ip address 40.40.40.2/24	Configure IPv4 address for xe5
(config-if)#label-switching	Enable label switching on interface xe5.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32.
(config-if)#commit	Commit the transaction.

PE2 - LDP

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 3.3.3.3	Set the router ID to IP address 3.3.3.3
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe10	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe10.
(config)#interface xe5	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe5.
(config-if)#commit	Commit the transaction.

PE2 - OSPF

(config)#router ospf 1	Configure the routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure Router ID
(config-router)#network 3.3.3.3/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 20.20.20.2/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 40.40.40.2/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

Validation

Without session protection enabled

Verify that session protection status is not shown when session protection not enabled.

```
PE1#show ip route
```

```
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default
```

```
IP Route Table for VRF "default"
```

```
C          1.1.1.1/32 is directly connected, lo, 00:04:22
```

```

O      2.2.2.2/32 [110/2] via 10.10.10.2, xe12, 00:03:03
O      3.3.3.3/32 [110/3] via 10.10.10.2, xe12, 00:02:49
O      4.4.4.4/32 [110/31] via 30.30.30.2, xe6, 00:02:17
C      10.10.10.0/24 is directly connected, xe12, 00:03:48
O      20.20.20.0/24 [110/2] via 10.10.10.2, xe12, 00:03:03
C      30.30.30.0/24 is directly connected, xe6, 00:03:02
O      40.40.40.0/24 [110/31] via 30.30.30.2, xe6, 00:02:17
C      127.0.0.0/8 is directly connected, lo, 00:04:22

```

Gateway of last resort is not set

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
4.4.4.4	xe6	Passive	OPERATIONAL	30	00:02:25
2.2.2.2	xe12	Passive	OPERATIONAL	30	00:03:11

PE1#show ldp targeted-peers

PE1#show ldp session 2.2.2.2

```

Session state      : OPERATIONAL
Session role       : Passive
TCP Connection     : Established
IP Address for TCP : 2.2.2.2
Interface being used : xe12
Peer LDP ID        : 2.2.2.2:0
Peer LDP Password   : Not Set
Adjacencies        : 10.10.10.2
Advertisement mode  : Downstream Unsolicited
Label retention mode : Liberal
Graceful Restart    : Not Capable
Keepalive Timeout   : 30
Reconnect Interval  : 15
Address List received : 2.2.2.2
                     10.10.10.2
                     20.20.20.1
                     254.128.0.0

```

Received Labels :	Fec	Label	Maps To
	IPV4:3.3.3.3/32	52480	24963
	IPV4:20.20.20.0/24	impl-null	24964
	IPV4:10.10.10.0/24	impl-null	none
	IPV4:2.2.2.2/32	impl-null	24962
Sent Labels :	Fec	Label	Maps To
	IPV4:40.40.40.0/24	24961	impl-null
	IPV4:4.4.4.4/32	24960	impl-null
	IPV4:30.30.30.0/24	impl-null	none
	IPV4:10.10.10.0/24	impl-null	none
	IPV4:1.1.1.1/32	impl-null	none

PE1#show mpls forwarding-table

```

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

```

(m) - FTN mapped over multipath transport

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	2	-	Yes	LSP_DEFAULT	3
xe12	No	10.10.10.2					
L>	3.3.3.3/32	3	5	-	Yes	LSP_DEFAULT	52480
xe12	No	10.10.10.2					
L>	4.4.4.4/32	4	7	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					
L>	20.20.20.0/24	2	3	-	Yes	LSP_DEFAULT	3
xe12	No	10.10.10.2					
L>	40.40.40.0/24	5	8	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					

PE1#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe12, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 4

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe12, out label: 52480

Nexthop addr: 10.10.10.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3

Nexthop addr: 30.30.30.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 20.20.20.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe12, out label: 3
 Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 5, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
 Nexthop addr: 30.30.30.2 cross connect ix: 4, op code: Push

PE1#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM

K - CLI ILM, T - MPLS-TP, s - Stitched ILM

S - SNMP, L - LDP, R - RSVP, C - CRLDP

B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT

O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI

P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nexthop		LSP-Type				
L>	3.3.3.3/32	4	24963	52480	N/A	xe12
10.10.10.2		LSP_DEFAULT				
L>	40.40.40.0/24	2	24961	3	N/A	xe6
30.30.30.2		LSP_DEFAULT				
L>	4.4.4.4/32	1	24960	3	N/A	xe6
30.30.30.2		LSP_DEFAULT				
L>	2.2.2.2/32	3	24962	3	N/A	xe12
10.10.10.2		LSP_DEFAULT				
L>	20.20.20.0/24	5	24964	3	N/A	xe12
10.10.10.2		LSP_DEFAULT				

PE1#show ldp fec

LSR codes : E/N - LSR is egress/non-egress for this FEC,

L - LSR received a label for this FEC,

> - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	E >	non-existent	none	No	connected
2.2.2.2/32	NL>	2.2.2.2	impl-null	No	10.10.10.2
3.3.3.3/32	NL	4.4.4.4	24325	No	no nexthop
	NL>	2.2.2.2	52480	No	10.10.10.2
4.4.4.4/32	NL>	4.4.4.4	impl-null	No	30.30.30.2
10.10.10.0/24	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
20.20.20.0/24	NL	4.4.4.4	24326	No	no nexthop
	NL>	2.2.2.2	impl-null	No	10.10.10.2
30.30.30.0/24	NL	4.4.4.4	impl-null	No	connected
	E >	non-existent	none	No	connected

```
40.40.40.0/24      NL>      4.4.4.4      impl-null  No      30.30.30.2
```

Configure Session Protection:

Note: Recommended to configure both ends.

Configure session protection under LDP in both nodes.

PE1

(config)#router ldp	Enter Router mode for LDP.
(config-router)#session-protection	Session-protection protect label indefinitely if no timer mentioned.
(config-router)#commit	Commit and exit

P1

(config)#router ldp	Enter Router mode for LDP.
(config-router)#session-protection	Session-protection protect label indefinitely if no timer mentioned.
(config-router)#commit	Commit and exit

Validation

With session protection command enabled

Verify that session protection status shown once session protection enabled in both peer nodes.

```
PE1#show ldp session
Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
4.4.4.4              xe6        Passive    OPERATIONAL 30         00:05:46
2.2.2.2              xe12       Passive    OPERATIONAL 30         00:06:32
PE1#show ldp targeted-peers
IP Address           Interface
2.2.2.2              xe12
4.4.4.4              xe6
PE1#show ldp session 2.2.2.2
Session state        : OPERATIONAL
Session role         : Passive
TCP Connection       : Established
IP Address for TCP   : 2.2.2.2
Interface being used : xe12
Peer LDP ID          : 2.2.2.2:0
Peer LDP Password    : Not Set
Adjacencies          : 10.10.10.2
                     : 2.2.2.2
Advertisement mode    : Downstream Unsolicited
Label retention mode : Liberal
Graceful Restart     : Not Capable
```

```

Keepalive Timeout      : 30
Reconnect Interval    : 15
Session protection     : Ready
Address List received  : 2.2.2.2
                        10.10.10.2
                        20.20.20.1
                        254.128.0.0

```

```

Received Labels :      Fec                Label                Maps To
                   IPV4:3.3.3.3/32          52480                 24963
                   IPV4:20.20.20.0/24       impl-null             24964
                   IPV4:10.10.10.0/24       impl-null             none
                   IPV4:2.2.2.2/32          impl-null             24962

Sent Labels :      Fec                Label                Maps To
                   IPV4:40.40.40.0/24       24961                 impl-null
                   IPV4:4.4.4.4/32          24960                 impl-null
                   IPV4:30.30.30.0/24       impl-null             none
                   IPV4:10.10.10.0/24       impl-null             none
                   IPV4:1.1.1.1/32          impl-null             none

```

PE1#show mpls forwarding-table

```

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
L>	2.2.2.2/32	1	2	-	Yes	LSP_DEFAULT	3
xe12	No	10.10.10.2					
L>	3.3.3.3/32	3	5	-	Yes	LSP_DEFAULT	52480
xe12	No	10.10.10.2					
L>	4.4.4.4/32	4	7	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					
L>	20.20.20.0/24	2	3	-	Yes	LSP_DEFAULT	3
xe12	No	10.10.10.2					
L>	40.40.40.0/24	5	8	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					

PE1#show mpls ilm-table

```

Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
        S - SNMP, L - LDP, R - RSVP, C - CRLDP
        B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
        O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
        P - SR Policy, U - unknown

```

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
L>	3.3.3.3/32	4	24963	52480	N/A	xe12
10.10.10.2		LSP_DEFAULT				
L>	40.40.40.0/24	2	24961	3	N/A	xe6
30.30.30.2		LSP_DEFAULT				
L>	4.4.4.4/32	1	24960	3	N/A	xe6
30.30.30.2		LSP_DEFAULT				

```
L> 2.2.2.2/32      3      24962      3      N/A      xe12
10.10.10.2      LSP_DEFAULT
L> 20.20.20.0/24   5      24964      3      N/A      xe12
10.10.10.2      LSP_DEFAULT
PE1#show mpls ftn-table
Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe12, out label: 3
Nexthop addr: 10.10.10.2      cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe12, out label: 52480
Nexthop addr: 10.10.10.2      cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
Nexthop addr: 30.30.30.2      cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 20.20.20.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe12, out label: 3
Nexthop addr: 10.10.10.2      cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 5, row status: Active, Tunnel-Policy: N/
A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
```

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
 Nexthop addr: 30.30.30.2 cross connect ix: 4, op code: Push

PE1#show ldp fec

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	E >	non-existent	none	No	connected
2.2.2.2/32	NL>	2.2.2.2	impl-null	No	10.10.10.2
3.3.3.3/32	NL	4.4.4.4	24325	No	no nexthop
	NL>	2.2.2.2	52480	No	10.10.10.2
4.4.4.4/32	NL>	4.4.4.4	impl-null	No	30.30.30.2
10.10.10.0/24	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
20.20.20.0/24	NL	4.4.4.4	24326	No	no nexthop
	NL>	2.2.2.2	impl-null	No	10.10.10.2
30.30.30.0/24	NL	4.4.4.4	impl-null	No	connected
	E >	non-existent	none	No	connected
40.40.40.0/24	NL>	4.4.4.4	impl-null	No	30.30.30.2

P1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
3.3.3.3	xe5	Passive	OPERATIONAL	30	00:05:40
1.1.1.1	xe48	Active	OPERATIONAL	30	00:06:43

P1#show ldp targeted-peers

IP Address	Interface
1.1.1.1	xe48
3.3.3.3	xe5

P1#show ldp session 1.1.1.1

Session state : OPERATIONAL
 Session role : Active
 TCP Connection : Established
 IP Address for TCP : 1.1.1.1
 Interface being used : xe48
 Peer LDP ID : 1.1.1.1:0
 Peer LDP Password : Not Set
 Adjacencies : 10.10.10.1
 1.1.1.1
 Advertisement mode : Downstream Unsolicited
 Label retention mode : Liberal
 Graceful Restart : Not Capable
 Keepalive Timeout : 30
 Reconnect Interval : 15
 Session protection : Ready
 Address List received : 1.1.1.1

```

10.10.10.1
30.30.30.1
254.128.0.0
Received Labels :      Fec          Label          Maps To
                    IPV4:4.4.4.4/32    24960          52482
                    IPV4:40.40.40.0/24 24961          52484
                    IPV4:30.30.30.0/24 impl-null      52483
                    IPV4:10.10.10.0/24 impl-null      none
                    IPV4:1.1.1.1/32    impl-null      52481
Sent Labels :      Fec          Label          Maps To
                    IPV4:3.3.3.3/32    52480          impl-null
                    IPV4:20.20.20.0/24 impl-null      none
                    IPV4:10.10.10.0/24 impl-null      none
                    IPV4:2.2.2.2/32    impl-null      none

```

P1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L> xe48	1.1.1.1/32 No	1 10.10.10.1	2	-	Yes	LSP_DEFAULT	3
L> xe5	3.3.3.3/32 No	5 20.20.20.2	9	-	Yes	LSP_DEFAULT	3
L> xe48	4.4.4.4/32 No	3 10.10.10.1	5	-	Yes	LSP_DEFAULT	24960
L> xe48	30.30.30.0/24 No	2 10.10.10.1	3	-	Yes	LSP_DEFAULT	3
L> xe48	40.40.40.0/24 No	4 10.10.10.1	7	-	Yes	LSP_DEFAULT	24961

P1#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, s - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nexthop		LSP-Type				
L> 10.10.10.1	30.30.30.0/24	4 LSP_DEFAULT	52483	3	N/A	xe48
L> 10.10.10.1	1.1.1.1/32	2 LSP_DEFAULT	52481	3	N/A	xe48
L> 20.20.20.2	3.3.3.3/32	1 LSP_DEFAULT	52480	3	N/A	xe5
L> 10.10.10.1	4.4.4.4/32	3 LSP_DEFAULT	52482	24960	N/A	xe48

```
L> 40.40.40.0/24      5      52484      24961      N/A      xe48
10.10.10.1          LSP_DEFAULT
Pl#show mpls ftn-table
Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe48, out label: 3
Nexthop addr: 10.10.10.1      cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: N/A, Stale: NO, out intf: xe5, out label: 3
Nexthop addr: 20.20.20.2      cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe48, out label: 24960
Nexthop addr: 10.10.10.1      cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 30.30.30.0/24, id: 2, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe48, out label: 3
Nexthop addr: 10.10.10.1      cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 4, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe48, out label: 24961
Nexthop addr: 10.10.10.1      cross connect ix: 4, op code: Push
```

```
Pl#show ldp fec
```

```
LSR codes      : E/N - LSR is egress/non-egress for this FEC,
                  L - LSR received a label for this FEC,
                  > - LSR will use this route for the FEC
```

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	NL>	1.1.1.1	impl-null	No	10.10.10.1
2.2.2.2/32	E >	non-existent	none	No	connected
3.3.3.3/32	NL>	3.3.3.3	impl-null	No	20.20.20.2
4.4.4.4/32	NL>	1.1.1.1	24960	No	10.10.10.1
10.10.10.0/24	NL	1.1.1.1	impl-null	No	connected
	E >	non-existent	none	No	connected
20.20.20.0/24	NL	3.3.3.3	impl-null	No	connected
	E >	non-existent	none	No	connected
30.30.30.0/24	NL>	1.1.1.1	impl-null	No	10.10.10.1
40.40.40.0/24	NL	3.3.3.3	impl-null	No	no nexthop
	NL>	1.1.1.1	24961	No	10.10.10.1

Perform Link failure and check labels are retained until peer is reachable through alternate path.

(config)#interface xe12	Enter interface mode.
(config-if)#shutdown	Shutdown the link.
(config)#commit	commit.

Validation

After link down

```
PE1#show ip route
```

```
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default
```

```
IP Route Table for VRF "default"
```

```
C      1.1.1.1/32 is directly connected, lo, 00:14:17
O      2.2.2.2/32 [110/33] via 30.30.30.2, xe6, 00:03:38
O      3.3.3.3/32 [110/32] via 30.30.30.2, xe6, 00:03:38
O      4.4.4.4/32 [110/31] via 30.30.30.2, xe6, 00:12:12
O      20.20.20.0/24 [110/32] via 30.30.30.2, xe6, 00:03:38
C      30.30.30.0/24 is directly connected, xe6, 00:12:57
O      40.40.40.0/24 [110/31] via 30.30.30.2, xe6, 00:12:12
C      127.0.0.0/8 is directly connected, lo, 00:14:17
```

```
PE1#show ldp session
```

Peer	IP Address	IF Name	My Role	State	KeepAlive	UpTime
------	------------	---------	---------	-------	-----------	--------


```

4.4.4.4          xe6          Passive  OPERATIONAL  30    00:10:10
2.2.2.2          xe6          Passive  OPERATIONAL  30    00:10:56

```

```

PE1#show ldp targeted-peers

```

```

IP Address      Interface
2.2.2.2         xe6
4.4.4.4         xe6/

```

```

PE1#show ldp session 2.2.2.2

```

```

Session state      : OPERATIONAL
Session role       : Passive
TCP Connection     : Established
IP Address for TCP : 2.2.2.2
Interface being used : xe6
Peer LDP ID        : 2.2.2.2:0
Peer LDP Password   : Not Set
Adjacencies        : 2.2.2.2
Advertisement mode  : Downstream Unsolicited
Label retention mode : Liberal
Graceful Restart   : Not Capable
Keepalive Timeout  : 30
Reconnect Interval : 15
Session protection : Protecting
Address List received : 2.2.2.2
                    20.20.20.1
                    254.128.0.0

```

```

Received Labels :      Fec          Label          Maps To
                   IPV4:3.3.3.3/32      52480          none
                   IPV4:20.20.20.0/24    impl-null      none
                   IPV4:10.10.10.0/24    impl-null      none
                   IPV4:2.2.2.2/32      impl-null      none
Sent Labels :      Fec          Label          Maps To
                   IPV4:40.40.40.0/24    24961          impl-null
                   IPV4:4.4.4.4/32      24960          impl-null
                   IPV4:30.30.30.0/24    impl-null      none
                   IPV4:10.10.10.0/24    impl-null      none
                   IPV4:1.1.1.1/32      impl-null      none

```

```

PE1#show mpls forwarding-table

```

```

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	3	9	-	Yes	LSP_DEFAULT	24321
xe6	No	30.30.30.2					
L>	3.3.3.3/32	1	2	-	Yes	LSP_DEFAULT	24325
xe6	No	30.30.30.2					
L>	4.4.4.4/32	4	7	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					

```

L> 20.20.20.0/24      2      4      -      Yes  LSP_DEFAULT  24326
xe6      No      30.30.30.2

L> 40.40.40.0/24      5      8      -      Yes  LSP_DEFAULT   3
xe6      No      30.30.30.2

```

```
PE1#show mpls ftn-table
```

```

Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

```

```

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe6, out label: 24321
Nexthop addr: 30.30.30.2      cross connect ix: 3, op code: Push

```

```

Primary FTN entry with FEC: 3.3.3.3/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

```

```

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: LDP, Stale: NO, out intf: xe6, out label: 24325
Nexthop addr: 30.30.30.2      cross connect ix: 1, op code: Push

```

```

Primary FTN entry with FEC: 4.4.4.4/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

```

```

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
Nexthop addr: 30.30.30.2      cross connect ix: 4, op code: Push

```

```

Primary FTN entry with FEC: 20.20.20.0/24, id: 2, row status: Active, Tunnel-Policy: N/A

```

```

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

```

```

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 3
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe6, out label: 24326
Nexthop addr: 30.30.30.2      cross connect ix: 2, op code: Push

```

```

Primary FTN entry with FEC: 40.40.40.0/24, id: 5, row status: Active, Tunnel-Policy: N/A

```

```

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

```

```

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

```

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
 Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
 Nexthop addr: 30.30.30.2 cross connect ix: 4, op code: Push

PE1#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, s - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nexthop		LSP-Type				
L>	40.40.40.0/24	2	24961	3	N/A	xe6
	30.30.30.2	LSP_DEFAULT				
L>	4.4.4.4/32	1	24960	3	N/A	xe6
	30.30.30.2	LSP_DEFAULT				

P1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
3.3.3.3	xe5	Passive	OPERATIONAL	30	00:11:12
1.1.1.1	xe5	Active	OPERATIONAL	30	00:12:15

P1#show ldp targeted-peers

IP Address	Interface
1.1.1.1	xe5
3.3.3.3	xe5

P1#show ldp session 1.1.1.1

Session state : OPERATIONAL
 Session role : Active
 TCP Connection : Established
 IP Address for TCP : 1.1.1.1
 Interface being used : xe5
 Peer LDP ID : 1.1.1.1:0
 Peer LDP Password : Not Set
 Adjacencies : 1.1.1.1
 Advertisement mode : Downstream Unsolicited
 Label retention mode : Liberal
 Graceful Restart : Not Capable
 Keepalive Timeout : 30
 Reconnect Interval : 15
 Session protection : Protecting
 Address List received : 1.1.1.1
 30.30.30.1
 254.128.0.0

Received Labels :	Fec	Label	Maps To
	IPV4:4.4.4.4/32	24960	52482
	IPV4:40.40.40.0/24	24961	52484

```

                IPV4:30.30.30.0/24      impl-null      52483
                IPV4:10.10.10.0/24      impl-null      none
                IPV4:1.1.1.1/32         impl-null      52481
Sent Labels :   Fec                     Label          Maps To
                IPV4:3.3.3.3/32         52480          impl-null
                IPV4:20.20.20.0/24      impl-null      none
                IPV4:10.10.10.0/24      impl-null      none
                IPV4:2.2.2.2/32         impl-null      none

```

P1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	1.1.1.1/32	2	3	-	Yes	LSP_DEFAULT	24965
xe5	No	20.20.20.2					
L>	3.3.3.3/32	5	9	-	Yes	LSP_DEFAULT	3
xe5	No	20.20.20.2					
L>	4.4.4.4/32	3	5	-	Yes	LSP_DEFAULT	24966
xe5	No	20.20.20.2					
L>	30.30.30.0/24	4	7	-	Yes	LSP_DEFAULT	24967
xe5	No	20.20.20.2					
L>	40.40.40.0/24	1	1	-	Yes	LSP_DEFAULT	3
xe5	No	20.20.20.2					

P1#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, s - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nexthop		LSP-Type				
L>	4.4.4.4/32	3	52482	Nolabel	N/A	N/A
127.0.0.1		LSP_DEFAULT				
L>	3.3.3.3/32	1	52480	3	N/A	xe5
20.20.20.2		LSP_DEFAULT				
L>	1.1.1.1/32	2	52481	Nolabel	N/A	N/A
127.0.0.1		LSP_DEFAULT				
L>	30.30.30.0/24	4	52483	Nolabel	N/A	N/A
127.0.0.1		LSP_DEFAULT				
L>	40.40.40.0/24	5	52484	Nolabel	N/A	N/A
127.0.0.1		LSP_DEFAULT				

P1#

P1#show mpls ftn-table

Primary FTN entry with FEC: 1.1.1.1/32, id: 2, row status: Active
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, Description: N/A
 Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 2

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xe5, out label: 24965
Nexthop addr: 20.20.20.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: N/A, Stale: NO, out intf: xe5, out label: 3
Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe5, out label: 24966
Nexthop addr: 20.20.20.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 30.30.30.0/24, id: 4, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe5, out label: 24967
Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 1, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: N/A, Stale: NO, out intf: xe5, out label: 3
Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Pl#show ip route

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,

ia - IS-IS inter area, E - EVPN,
v - vrf leaked
* - candidate default

IP Route Table for VRF "default"

```
O      1.1.1.1/32 [110/53] via 20.20.20.2, xe5, 00:03:44
C      2.2.2.2/32 is directly connected, lo, 00:14:13
O      3.3.3.3/32 [110/2] via 20.20.20.2, xe5, 00:12:51
O      4.4.4.4/32 [110/52] via 20.20.20.2, xe5, 00:03:44
C      20.20.20.0/24 is directly connected, xe5, 00:13:46
O      30.30.30.0/24 [110/52] via 20.20.20.2, xe5, 00:03:44
O      40.40.40.0/24 [110/51] via 20.20.20.2, xe5, 00:03:44
C      127.0.0.0/8 is directly connected, lo, 00:14:13
```

Bring up the link and check same labels reused.

(config)#interface xe12	Enter interface mode.
(config-if)#no shutdown	Shutdown the link.
(config)#commit	Commit.

Validation

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
4.4.4.4	xe6	Passive	OPERATIONAL	30	00:14:55
2.2.2.2	xe12	Passive	OPERATIONAL	30	00:15:41

PE1#show ldp targeted-peers

IP Address	Interface
2.2.2.2	xe12
4.4.4.4	xe6

PE1#show ldp session 2.2.2.2

```
Session state      : OPERATIONAL
Session role       : Passive
TCP Connection     : Established
IP Address for TCP : 2.2.2.2
Interface being used : xe12
Peer LDP ID        : 2.2.2.2:0
Peer LDP Password  : Not Set
Adjacencies        : 10.10.10.2
                   : 2.2.2.2
Advertisement mode  : Downstream Unsolicited
Label retention mode : Liberal
Graceful Restart   : Not Capable
Keepalive Timeout  : 30
Reconnect Interval : 15
Session protection : Ready
Address List received : 2.2.2.2
```

```

10.10.10.2
20.20.20.1
254.128.0.0
Received Labels :      Fec          Label          Maps To
                    IPV4:3.3.3.3/32    52480          24966
                    IPV4:20.20.20.0/24 impl-null      24967
                    IPV4:10.10.10.0/24 impl-null      none
                    IPV4:2.2.2.2/32    impl-null      24965
Sent Labels :      Fec          Label          Maps To
                    IPV4:40.40.40.0/24 24961          impl-null
                    IPV4:4.4.4.4/32    24960          impl-null
                    IPV4:30.30.30.0/24 impl-null      none
                    IPV4:10.10.10.0/24 impl-null      none
                    IPV4:1.1.1.1/32    impl-null      none

```

PE1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
 (m) - FTN mapped over multipath transport

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	3	9	-	Yes	LSP_DEFAULT	3
xe12	No	10.10.10.2					
L>	3.3.3.3/32	1	2	-	Yes	LSP_DEFAULT	52480
xe12	No	10.10.10.2					
L>	4.4.4.4/32	4	7	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					
L>	20.20.20.0/24	2	4	-	Yes	LSP_DEFAULT	3
xe12	No	10.10.10.2					
L>	40.40.40.0/24	5	8	-	Yes	LSP_DEFAULT	3
xe6	No	30.30.30.2					

PE1#

PE1#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, s - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nexthop		LSP-Type				
L>	2.2.2.2/32	9	24965	3	N/A	xe12
10.10.10.2		LSP_DEFAULT				
L>	40.40.40.0/24	2	24961	3	N/A	xe6
30.30.30.2		LSP_DEFAULT				
L>	4.4.4.4/32	1	24960	3	N/A	xe6
30.30.30.2		LSP_DEFAULT				
L>	3.3.3.3/32	10	24966	52480	N/A	xe12
10.10.10.2		LSP_DEFAULT				

```
L> 20.20.20.0/24      11      24967      3      N/A      xe12
10.10.10.2          LSP_DEFAULT
PE1#show mpls ftn-table
Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 10
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe12, out label: 3
Nexthop addr: 10.10.10.2      cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 11
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe12, out label: 52480
Nexthop addr: 10.10.10.2      cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
Nexthop addr: 30.30.30.2      cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 20.20.20.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 10
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe12, out label: 3
Nexthop addr: 10.10.10.2      cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 5, row status: Active, Tunnel-Policy: N/
A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
```

NextHop addr: 30.30.30.2 cross connect ix: 4, op code: Push

P1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
3.3.3.3	xe5	Passive	OPERATIONAL	30	00:15:30
1.1.1.1	xe48	Active	OPERATIONAL	30	00:16:33

P1#show ldp targeted-peers

IP Address	Interface
1.1.1.1	xe48
3.3.3.3	xe5

P1#show ldp session 1.1.1.1

Session state : OPERATIONAL
Session role : Active
TCP Connection : Established
IP Address for TCP : 1.1.1.1
Interface being used : xe48
Peer LDP ID : 1.1.1.1:0
Peer LDP Password : Not Set
Adjacencies : 10.10.10.1
1.1.1.1
Advertisement mode : Downstream Unsolicited
Label retention mode : Liberal
Graceful Restart : Not Capable
Keepalive Timeout : 30
Reconnect Interval : 15
Session protection : Ready
Address List received : 1.1.1.1
10.10.10.1
30.30.30.1
254.128.0.0

Received Labels :	Fec	Label	Maps To
	IPV4:4.4.4.4/32	24960	52482
	IPV4:40.40.40.0/24	24961	52484
	IPV4:30.30.30.0/24	impl-null	52483
	IPV4:10.10.10.0/24	impl-null	none
	IPV4:1.1.1.1/32	impl-null	52481
Sent Labels :	Fec	Label	Maps To
	IPV4:3.3.3.3/32	52480	impl-null
	IPV4:20.20.20.0/24	impl-null	none
	IPV4:10.10.10.0/24	impl-null	none
	IPV4:2.2.2.2/32	impl-null	none

P1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
B - BGP FTN, K - CLI FTN, t - tunnel,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nextthop					
L>	1.1.1.1/32	2	3	-	Yes	LSP_DEFAULT	3
xe48	No	10.10.10.1					
L>	3.3.3.3/32	5	9	-	Yes	LSP_DEFAULT	3
xe5	No	20.20.20.2					
L>	4.4.4.4/32	3	5	-	Yes	LSP_DEFAULT	24960
xe48	No	10.10.10.1					
L>	30.30.30.0/24	4	7	-	Yes	LSP_DEFAULT	3
xe48	No	10.10.10.1					
L>	40.40.40.0/24	1	1	-	Yes	LSP_DEFAULT	24961
xe48	No	10.10.10.1					

Pl#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM

K - CLI ILM, T - MPLS-TP, s - Stitched ILM

S - SNMP, L - LDP, R - RSVP, C - CRLDP

B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT

U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nextthop		LSP-Type				
L>	4.4.4.4/32	3	52482	24960	N/A	xe48
10.10.10.1		LSP_DEFAULT				
L>	1.1.1.1/32	2	52481	3	N/A	xe48
10.10.10.1		LSP_DEFAULT				
L>	3.3.3.3/32	1	52480	3	N/A	xe5
20.20.20.2		LSP_DEFAULT				
L>	40.40.40.0/24	5	52484	24961	N/A	xe48
10.10.10.1		LSP_DEFAULT				
L>	30.30.30.0/24	4	52483	3	N/A	xe48
10.10.10.1		LSP_DEFAULT				

Pl#show mpls ftn-table

Primary FTN entry with FEC: 1.1.1.1/32, id: 2, row status: Active

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A

Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 10

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe48, out label: 3

Nextthop addr: 10.10.10.1 cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 8, owner: N/A, Stale: NO, out intf: xe5, out label: 3

Nextthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 11
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe48, out label: 24960
Nexthop addr: 10.10.10.1 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 30.30.30.0/24, id: 4, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 10
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe48, out label: 3
Nexthop addr: 10.10.10.1 cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 1, row status: Active
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 12
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe48, out label: 24961
Nexthop addr: 10.10.10.1 cross connect ix: 8, op code: Push

CHAPTER 2 LDP Inter-Area Configuration

This chapter contains LDP inter-area configuration examples.

Overview

Provider-based MPLS (Multiprotocol Label Switching) networks are expanding with the success of Layer 3 Virtual Private Networks and the new deployments of Layer 2 VPNs. Service providers MPLS backbones are significantly growing both in terms of density with the addition of Provider Edge (PE) routers to connect new customers and in terms of footprint as traditional Layer 2 aggregation networks may be replaced by IP/MPLS networks. As a consequence, many providers need to introduce IGP areas. Inter-area LSPs (that is, LSPs that traverse at least two IGP areas) are required to ensure MPLS connectivity between PEs located in distinct IGP areas.

On a large MPLS networks, multiple IGP areas need to be configured for flexible network deployment and fast route convergence. When advertising routes between IGP areas, to prevent a large number of routes from consuming too many resources, an Area Border Router (ABR) needs to aggregate the routes in the area and advertises the aggregated route to the neighboring IGP areas. By default, when establishing LSPs, LDP searches the routing table for the route that exactly matches the FEC in the received Label Mapping message.

The LDP inter-area feature provides a longest-match label mapping procedure where a label is used if the Forwarding Equivalence Class (FEC) matches an entry in the Routing Information Base (RIB). Matching is defined by an IP longest-match search and does not mandate an exact match.

Configure LDP Inter-Area

The LDP Inter-Area configuration process can be divided into the following tasks:

1. Enable label-switching on the interface in NSM.
2. Enable LDP on an interface in LDP.
3. Run an IGP (Internal Gateway Protocol) such as OSPF or ISIS to distribute reachability information within the MPLS cloud.
4. Give the `inter-area-lsp` command in LDP router mode to enable creation of inter-area LSPs.

To configure a summary route on an ABR, configure two networks such R4 and R5 in [Figure 2-1](#), so that two prefixes are summarized. For example, 4.4.4.0/24 is a summary route for the networks 4.4.4.1/32 and 4.4.4.2/32.

Give the `area-range` command on the routers to summarize the networks. For example: `area 2 range 4.4.4.0/24`.

Note: LDP Downstream-On-Demand not supported with inter-area configuration. LDP Inter-Area Graceful Restart (GR) is not supported in this release.

Topology

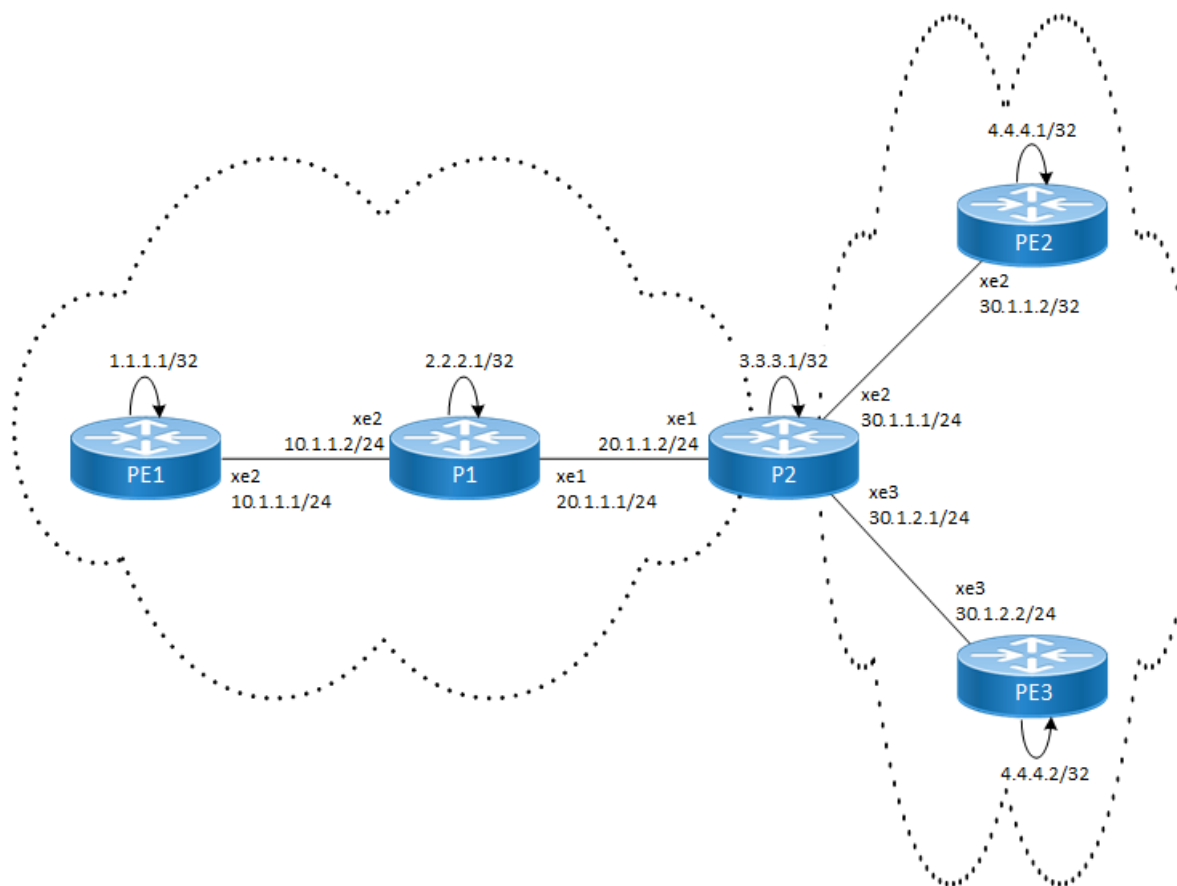


Figure 2-1: LDP inter-area topology

PE1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter loopback interface mode.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 4.4.4.1	Configure targeted peer.
(config-router-targeted-peer)#targeted-peer ipv4 4.4.4.2	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode.
(config)#interface xe2	Enter interface mode.

(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 10.1.1.1/24	Set the IP address of the interface to 10.1.1.1/24
(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
(config-router)#network 1.1.1.1/32 area 0 (config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter LDP router mode.
(config-router)#inter-area-lsp	Enable the inter-area-LSP command.
(config-router)#commit	Commit the transaction.

P1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 2.2.2.1	Set the router ID to IP address 2.2.2.1
(config-router)#transport-address ipv4 2.2.2.1	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter loopback interface mode.
(config-if)#ip address 2.2.2.1/32	Set the IP address of the loopback interface to 2.2.2.1/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 10.1.1.2/24	Set the IP address of the interface to 10.1.1.2/24
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#ip address 20.1.1.1/24	Set the IP address of the interface to 20.1.1.1/24
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the routing process and specify the Process ID (1).

(config-router)#network 2.2.2.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.1.0/24 area 0	
(config-router)#network 20.1.1.0/24 area 0	
(config)#interface xe2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe1.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter LDP router mode.
(config-router)#inter-area-lsp	Enable the inter-area-LSP command.
(config-router)#commit	Commit the transaction.

P2

#configure terminal	Enter configure mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter loopback interface mode.
(config-if)#ip address 3.3.3.1/32 secondary	Set the IP address of the loopback interface to 3.3.3.1/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 20.1.1.2/24	Set the IP address of the interface to 20.1.1.2/24
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#ip address 30.1.1.1/24	Set the IP address of the interface to 30.1.1.1/24
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on xe1.
(config-if)#ip address 30.1.2.1/24	Set the IP address of the interface to 30.1.2.1/24
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
(config-router)#network 3.3.3.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0 and 2) respectively with the interface.
(config-router)#network 20.1.1.0/24 area 0	
(config-router)#network 30.1.1.0/24 area 2	
(config-router)#network 30.1.2.0/24 area 2	
(config)#router ldp	Enter LDP router mode.

(config-router)#transport-address ipv4 3.3.3.1	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#router-id 3.3.3.1	Set the router ID to IP address 3.3.3.1
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe3.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
(config-router)#area 2 range 4.4.4.0/24	Configure the summary route with range command.
(config-router)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#interface xe2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter loopback interface mode.
(config-if)#ip address 4.4.4.1/32 secondary	Set the IP address of the loopback interface to 4.4.4.1/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 30.1.1.2/24	Set the IP address of the interface to 30.1.1.2/24
(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
(config-router)#network 4.4.4.1/32 area 2	Define the interface on which OSPF runs and associate the area ID (2) with the interface.
(config-router)#network 30.1.1.0/24 area 2	
(config)#router ldp	Enter LDP router mode.
(config-router)#router-id 4.4.4.1	Set the router ID to IP address to 4.4.4.1
(config-router)#transport-address ipv4 4.4.4.1	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe2	Enter interface mode.

(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#commit	Commit the transaction.

PE3

#configure terminal	Enter configure mode.
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter loopback interface mode.
(config-if)#ip address 4.4.4.2/32 secondary	Set the IP address of the loopback interface to 4.4.4.2/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 30.1.2.2/24	Set the IP address of the interface to 30.1.2.2/24
(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
(config-router)#network 4.4.4.2/32 area 2	Define the interface on which OSPF runs and associate the area ID (2) with the interface.
(config-router)#network 30.1.2.0/24 area 2	
(config)#router ldp	Enter LDP router mode.
(config-router)#router-id 4.4.4.2	Set the router ID to IP address to 4.4.4.2
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe3	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe3.
(config-if)#commit	Commit the transaction.

Validation

PE1

```
PE1#show ip route
```

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP

O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,

ia - IS-IS inter area, E - EVPN,

v - vrf leaked

* - candidate default

IP Route Table for VRF "default"

Gateway of last resort is 10.12.49.1 to network 0.0.0.0

```

K*      0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C       1.1.1.1/32 is directly connected, lo, 00:30:03
O       2.2.2.1/32 [110/2] via 10.1.1.2, xe2, 00:19:09
O       3.3.3.1/32 [110/3] via 10.1.1.2, xe2, 00:12:28
O IA    4.4.4.0/24 [110/4] via 10.1.1.2, xe2, 00:08:42
C       10.1.1.0/24 is directly connected, xe2, 00:29:06
C       10.12.49.0/24 is directly connected, xe0, 01:32:26
O       20.1.1.0/24 [110/2] via 10.1.1.2, xe2, 00:19:09
O IA    30.1.1.0/24 [110/3] via 10.1.1.2, xe2, 00:12:28
O IA    30.1.2.0/24 [110/3] via 10.1.1.2, xe2, 00:12:28
C       127.0.0.0/8 is directly connected, lo, 01:33:35

```

PE1#show ldp inter-area-fecs

```

LSR codes      : E/N - LSR is egress/non-egress for this FEC,
                  L - LSR received a label for this FEC,
                  > - LSR will use this route for the FEC

```

FEC	Code	Session	Out Label	ELC	Nexthop Addr
Matching RIB prefix - 4.4.4.0/24					
4.4.4.1/32	NL>	2.2.2.1	25605	No	10.1.1.2
4.4.4.2/32	NL>	2.2.2.1	25606	No	10.1.1.2

PE1#show mpls forwarding-table

```

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC
Nexthop									
L>	2.2.2.1/32	1	2	-	Yes	LSP_DEFAULT	3	xe2	No
10.1.1.2	L>	3.3.3.1/32	3	-	Yes	LSP_DEFAULT	25600	xe2	No
10.1.1.2	L>	4.4.4.0/24	6	-	Yes	LSP_DEFAULT	25604	xe2	No
10.1.1.2	L>	4.4.4.1/32	7	-	Yes	LSP_DEFAULT	25605	xe2	No
10.1.1.2	L>	4.4.4.2/32	8	-	Yes	LSP_DEFAULT	25606	xe2	No
10.1.1.2	L>	20.1.1.0/24	2	-	Yes	LSP_DEFAULT	3	xe2	No
10.1.1.2	L>	30.1.1.0/24	4	-	Yes	LSP_DEFAULT	25601	xe2	No
10.1.1.2	L>	30.1.2.0/24	5	-	Yes	LSP_DEFAULT	25602	xe2	No

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.1	xe2	Passive	OPERATIONAL	30	00:19:02

P1

P1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe2	Active	OPERATIONAL	30	00:22:11
3.3.3.1	xe1	Passive	OPERATIONAL	30	00:16:34

P1#show ldp inter-area-fecs

```

LSR codes      : E/N - LSR is egress/non-egress for this FEC,
                  L - LSR received a label for this FEC,
                  > - LSR will use this route for the FEC

```

FEC	Code	Session	Out Label	ELC	Nexthop Addr
-----	------	---------	-----------	-----	--------------

Matching RIB prefix - 4.4.4.0/24

4.4.4.1/32	NL>	3.3.3.1	25600	No	20.1.1.2
4.4.4.2/32	NL>	3.3.3.1	25604	No	20.1.1.2

P1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
L>	1.1.1.1/32	1	2	-	Yes	LSP_DEFAULT	3	xe1	No	10.1.1.1
L>	3.3.3.1/32	2	3	-	Yes	LSP_DEFAULT	3	xe1	No	20.1.1.2
L>	4.4.4.0/24	6	3	-	Yes	LSP_DEFAULT	3	xe1	No	20.1.1.2
L>	4.4.4.1/32	5	4	-	Yes	LSP_DEFAULT	25600	xe1	No	20.1.1.2
L>	4.4.4.2/32	7	1	-	Yes	LSP_DEFAULT	25604	xe1	No	20.1.1.2
L>	30.1.1.0/24	3	3	-	Yes	LSP_DEFAULT	3	xe1	No	20.1.1.2
L>	30.1.2.0/24	4	3	-	Yes	LSP_DEFAULT	3	xe1	No	20.1.1.2

P1#show ip route

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
 O - OSPF, IA - OSPF inter area
 N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
 E1 - OSPF external type 1, E2 - OSPF external type 2
 i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
 ia - IS-IS inter area, E - EVPN,
 v - vrf leaked
 * - candidate default

IP Route Table for VRF "default"

Gateway of last resort is 10.12.49.1 to network 0.0.0.0

```

K*      0.0.0.0/0 [0/0] via 10.12.49.1, xe0
O       1.1.1.1/32 [110/2] via 10.1.1.1, xe2, 00:28:05
C       2.2.2.1/32 is directly connected, lo, 00:29:56
O       3.3.3.1/32 [110/2] via 20.1.1.2, xe1, 00:21:28
O IA    4.4.4.0/24 [110/3] via 20.1.1.2, xe1, 00:17:41
C       10.1.1.0/24 is directly connected, xe2, 00:29:29
C       10.12.49.0/24 is directly connected, xe0, 01:26:43
C       20.1.1.0/24 is directly connected, xe1, 00:29:06
O IA    30.1.1.0/24 [110/2] via 20.1.1.2, xe1, 00:21:28
O IA    30.1.2.0/24 [110/2] via 20.1.1.2, xe1, 00:21:28
C       127.0.0.0/8 is directly connected, lo, 01:30:20

```

P2

P2#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.1	xe1	Active	OPERATIONAL	30	00:18:30
4.4.4.1	xe2	Passive	OPERATIONAL	30	00:13:42
4.4.4.2	xe3	Passive	OPERATIONAL	30	00:08:51

P2#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
L>	1.1.1.1/32	1	1	-	Yes	LSP_DEFAULT	25603	xe1	No	20.1.1.1
L>	2.2.2.1/32	2	2	-	Yes	LSP_DEFAULT	3	xe1	No	20.1.1.1
L>	4.4.4.1/32	4	3	-	Yes	LSP_DEFAULT	3	xe2	No	30.1.1.2
L>	4.4.4.2/32	5	4	-	Yes	LSP_DEFAULT	3	xe3	No	30.1.2.2
L>	10.1.1.0/24	3	2	-	Yes	LSP_DEFAULT	3	xe1	No	20.1.1.1

P2#show ip route

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP

O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,

ia - IS-IS inter area, E - EVPN,

v - vrf leaked

* - candidate default

IP Route Table for VRF "default"

Gateway of last resort is 10.12.49.1 to network 0.0.0.0

```

K*      0.0.0.0/0 [0/0] via 10.12.49.1, xe0
O       1.1.1.1/32 [110/3] via 20.1.1.1, xe1, 00:20:52
O       2.2.2.1/32 [110/2] via 20.1.1.1, xe1, 00:20:52
C       3.3.3.1/32 is directly connected, lo, 00:23:04
O       4.4.4.0/24 [110/0] is a summary, Null, 00:17:09
O       4.4.4.1/32 [110/2] via 30.1.1.2, xe2, 00:17:09
O       4.4.4.2/32 [110/2] via 30.1.2.2, xe3, 00:10:38
O       10.1.1.0/24 [110/2] via 20.1.1.1, xe1, 00:20:52
C       10.12.49.0/24 is directly connected, xe0, 01:33:43
C       20.1.1.0/24 is directly connected, xe1, 00:22:46
C       30.1.1.0/24 is directly connected, xe2, 00:22:15
C       30.1.2.0/24 is directly connected, xe3, 00:21:48
C       127.0.0.0/8 is directly connected, lo, 01:35:10

```

PE2

PE2#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
3.3.3.1	xe2	Active	OPERATIONAL	30	00:14:56

PE2#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intfh	ELC	Nexthop					
L>	1.1.1.1/32	1	1	-	Yes	LSP_DEFAULT	25601
xe2	No	30.1.1.1					
L>	2.2.2.1/32	2	2	-	Yes	LSP_DEFAULT	25602
xe2	No	30.1.1.1					

```

L> 3.3.3.1/32 3 3 - Yes LSP_DEFAULT 3
xe2 No 30.1.1.1
L> 4.4.4.2/32 7 5 - Yes LSP_DEFAULT 25605
xe2 No 30.1.1.1
L> 10.1.1.0/24 4 4 - Yes LSP_DEFAULT 25603
xe2 No 30.1.1.1
L> 20.1.1.0/24 5 3 - Yes LSP_DEFAULT 3
xe2 No 30.1.1.1
L> 30.1.2.0/24 6 3 - Yes LSP_DEFAULT 3
xe2 No 30.1.1.1

```

PE2#show ip route

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
 O - OSPF, IA - OSPF inter area
 N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
 E1 - OSPF external type 1, E2 - OSPF external type 2
 i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
 ia - IS-IS inter area, E - EVPN,
 v - vrf leaked
 * - candidate default

IP Route Table for VRF "default"

Gateway of last resort is 10.12.49.1 to network 0.0.0.0

```

K* 0.0.0.0/0 [0/0] via 10.12.49.1, xe0
O IA 1.1.1.1/32 [110/4] via 30.1.1.1, xe2, 00:16:46
O IA 2.2.2.1/32 [110/3] via 30.1.1.1, xe2, 00:16:46
O IA 3.3.3.1/32 [110/2] via 30.1.1.1, xe2, 00:16:46
C 4.4.4.1/32 is directly connected, lo, 00:17:38
O 4.4.4.2/32 [110/3] via 30.1.1.1, xe2, 00:10:22
O IA 10.1.1.0/24 [110/3] via 30.1.1.1, xe2, 00:16:46
C 10.12.49.0/24 is directly connected, xe0, 01:24:27
O IA 20.1.1.0/24 [110/2] via 30.1.1.1, xe2, 00:16:46
C 30.1.1.0/24 is directly connected, xe2, 00:17:22
O 30.1.2.0/24 [110/2] via 30.1.1.1, xe2, 00:16:46
C 127.0.0.0/8 is directly connected, lo, 01:26:08

```

PE3

PE3#show ldp session

Peer	IP Address	IF Name	My Role	State	KeepAlive	UpTime
3.3.3.1		xe3	Active	OPERATIONAL	30	00:12:50

PE3#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
L>	1.1.1.1/32	1	1	-	Yes	LSP_DEFAULT	25606	xe3	No	30.1.2.1
L>	2.2.2.1/32	2	2	-	Yes	LSP_DEFAULT	25607	xe3	No	30.1.2.1
L>	3.3.3.1/32	3	3	-	Yes	LSP_DEFAULT	3	xe3	No	30.1.2.1
L>	4.4.4.1/32	4	4	-	Yes	LSP_DEFAULT	25608	xe3	No	30.1.2.1
L>	10.1.1.0/24	5	5	-	Yes	LSP_DEFAULT	25609	xe3	No	30.1.2.1
L>	20.1.1.0/24	6	3	-	Yes	LSP_DEFAULT	3	xe3	No	30.1.2.1
L>	30.1.1.0/24	7	3	-	Yes	LSP_DEFAULT	3	xe3	No	30.1.2.1

```
PE3#show ip route
```

```
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
```

```
       O - OSPF, IA - OSPF inter area
```

```
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
```

```
       E1 - OSPF external type 1, E2 - OSPF external type 2
```

```
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
```

```
       ia - IS-IS inter area, E - EVPN,
```

```
       v - vrf leaked
```

```
       * - candidate default
```

```
IP Route Table for VRF "default"
```

```
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
```

```
K*      0.0.0.0/0 [0/0] via 10.12.49.1, xe0
O IA    1.1.1.1/32 [110/4] via 30.1.2.1, xe3, 00:13:04
O IA    2.2.2.1/32 [110/3] via 30.1.2.1, xe3, 00:13:04
O IA    3.3.3.1/32 [110/2] via 30.1.2.1, xe3, 00:13:04
O       4.4.4.1/32 [110/3] via 30.1.2.1, xe3, 00:13:04
C       4.4.4.2/32 is directly connected, lo, 00:16:39
O IA    10.1.1.0/24 [110/3] via 30.1.2.1, xe3, 00:13:04
C       10.12.49.0/24 is directly connected, xe0, 00:57:36
O IA    20.1.1.0/24 [110/2] via 30.1.2.1, xe3, 00:13:04
O       30.1.1.0/24 [110/2] via 30.1.2.1, xe3, 00:13:04
C       30.1.2.0/24 is directly connected, xe3, 00:13:22
C       127.0.0.0/8 is directly connected, lo, 00:59:09
```

CHAPTER 3 MPLS LDP-IGP Synchronization

This chapter contains configurations for MPLS LDP-IGP Synchronization.

Overview

Multi-Protocol Label Switching (MPLS) Label Distribution Protocol (LDP) Interior Gateway Protocol (IGP) Synchronization ensures that LDP is fully established before the IGP path is used for switching. In certain networks, there is dependency on the edge-to-edge Label Switched Paths (LSPs) setup by the Label Distribution Protocol (LDP), e.g., networks that are used for Multi-Protocol Label Switching (MPLS) Virtual Private Network (VPN) applications. For such applications, it is not possible to rely on Internet Protocol (IP) forwarding if the MPLS LSP is not operating appropriately. Labeled traffic can be dropped due to presence of black holes in situations where the Interior Gateway Protocol (IGP) is operational on a link but LDP sessions are not up as the label distribution is not completed. While the link could still be used for IP forwarding, it is not useful for MPLS forwarding, for example, MPLS VPN applications or Border Gateway Protocol (BGP) route-free cores.

The MPLS LDP-IGP Synchronization feature ensures that the Label Distribution Protocol (LDP) is fully established before the Interior Gateway Protocol (IGP) path is used for packet forwarding. It is useful for cases in which the router is the ingress and the decision of whether to take the MPLS LSP or IGP path is decided there.

LDP-IGP synchronization is an interface level feature. It can be selectively enabled in the required interfaces. For each interface there are two commands available for synchronization, one each for IS-IS. Once configured the IGP saves the required information, and also notifies LDP. In between the IGP increases the link cost to maximum and sends advertisements to its peer. This discourages its peers from taking routes that pass via it.

When all LDP sessions hosted on the interface become operational, it sends a notification to the IGP. This is termed as LDP convergence. The IGP then advertises normal cost, so that all traffic now coming to the interface takes the MPLS LSP path established by LDP and not be IP routed.

Prerequisites

Only interfaces that are running Open Shortest Path First (OSPF) or Intermediate System-to-Intermediate System (IS-IS) processes are capable of LDP-IGP synchronization. The router must also be running LDP.

Topology

The sample topology diagram is applicable to all configurations in this chapter.

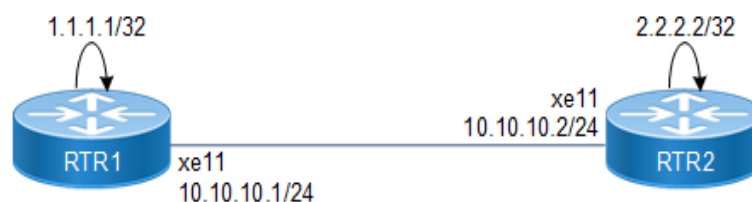


Figure 3-2: Sample Topology for LDP-IGP Synchronization

LDP-IGP Synchronization with OSPF

When IGP synchronization is enabled on OSPF-enabled interfaces, OSPF sends Maximum/Normal cost based on LDP session Down or Up state messages to interfaces until the hold-down-timer expires or synchronization is achieved.

Before configuring LDP-IGP synchronization, the NSM, OSPF and LDP configurations must be completed. The tables below contain examples of how this is done.

RTR1 - NSM

#configure terminal	Enter configuration mode.
(config)#interface xe11	Enter interface mode.
(config-if)#ip address 10.10.10.1/24	Configure IPv4 address for xe11.
(config-if)#label-switching	Enable label switching on interface xe11.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
(config-if)#commit	Commit the transaction.

RTR1 - OSPF

(config)#router ospf 100	Configure the routing process and specify the Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 1.1.1.1	Configure OSPF router ID same as loopback IP address.
(config-router)#network 10.10.10.0/24 area 0 (config-router)#network 1.1.1.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

RTR1 - LDP

(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1.
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe11	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe11.
(config-if)#commit	Commit the transaction.

RTR2 - NSM

#configure terminal	Enter configuration mode.
(config)#interface xe11	Enter interface mode.
(config-if)#ip address 10.10.10.2/24	Configure IPv4 address for xe11.
(config-if)#label-switching	Enable label switching on interface xe11.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if)#commit	Commit the transaction.

RTR2 - OSPF

(config)#router ospf 100	Configure the routing process and specify the Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 2.2.2.2	Configure OSPF router ID same as loopback IP address.
(config-router)#network 10.10.10.0/24 area 0 (config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

RTR2 - LDP

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as transport address.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe11	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe11.
(config-if)#commit	Commit the transaction.

Validation

```
R1#show ip ospf neighbor
```

```
Total number of full neighbors: 1
```

```
OSPF process 100 VRF(default):
```

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
2.2.2.2 0	1	Full/DR	00:00:33	10.10.10.2	xe11

```
R2#show ip ospf neighbor
```

```
Total number of full neighbors: 1
```

```
OSPF process 100 VRF(default):
```

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
1.1.1.1	1	Full/Backup	00:00:31	10.10.10.1	xe11

```
0
```

```
R1#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe11	Passive	OPERATIONAL	30	00:06:03

```
R2#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe11	Active	OPERATIONAL	30	00:06:31

```
R1#show ldp adjacency
```

Remote-Address	Local-Address	Mode	Intf-Name	Holdtime	LDP-Identifier
10.10.10.2	10.10.10.1	Interface	xe11	15	2.2.2.2:0

```
R2#show ldp adjacency
```

Remote-Address	Local-Address	Mode	Intf-Name	Holdtime	LDP-Identifier
10.10.10.1	10.10.10.2	Interface	xe11	15	1.1.1.1:0

```
R1#show ip ospf interface
```

```
lo is up, line protocol is up
```

```
Internet Address 1.1.1.1/32, Area 0.0.0.0, MTU 16436
```

```
Process ID 100, VRF (default), Router ID 1.1.1.1, Network Type LOOPBACK,  
Cost: 1
```

```
Transmit Delay is 1 sec, State Loopback, TE Metric 1
```

```
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
```

```
xe11 is up, line protocol is up
```

```
Internet Address 10.10.10.1/24, Area 0.0.0.0, MTU 1500
```

```
Process ID 100, VRF (default), Router ID 1.1.1.1, Network Type BROADCAST,  
Cost: 1
```

```
Transmit Delay is 1 sec, State Backup, Priority 1, TE Metric 1
```

```
Designated Router (ID) 2.2.2.2, Interface Address 10.10.10.2
```

```
Backup Designated Router (ID) 1.1.1.1, Interface Address 10.10.10.1
```

```
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
```

```
Hello due in 00:00:01
```

```
Neighbor Count is 1, Adjacent neighbor count is 1
```

```
Hello received 61 sent 62, DD received 3 sent 6
```

```
LS-Req received 1 sent 1, LS-Upd received 4 sent 5
```

```
LS-Ack received 4 sent 3, Discarded 0
```

```
No authentication
```

```
R2#show ip ospf interface
```

```
lo is up, line protocol is up
```

```
Internet Address 2.2.2.2/32, Area 0.0.0.0, MTU 16436
```

```
Process ID 100, VRF (default), Router ID 2.2.2.2, Network Type LOOPBACK,  
Cost: 1
```

```
Transmit Delay is 1 sec, State Loopback, TE Metric 1
```

```
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
```

```
xe11 is up, line protocol is up
```

```
Internet Address 10.10.10.2/24, Area 0.0.0.0, MTU 1500
```

```

Process ID 100, VRF (default), Router ID 2.2.2.2, Network Type BROADCAST,
Cost: 1
Transmit Delay is 1 sec, State DR, Priority 1, TE Metric 1
Designated Router (ID) 2.2.2.2, Interface Address 10.10.10.2
Backup Designated Router (ID) 1.1.1.1, Interface Address 10.10.10.1
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:01
Neighbor Count is 1, Adjacent neighbor count is 1
Hello received 62 sent 63, DD received 6 sent 3
LS-Req received 1 sent 1, LS-Upd received 5 sent 4
LS-Ack received 3 sent 4, Discarded 0
No authentication

```

LDP-IGP Synchronization

Now that NSM, OSPF and LDP are all enabled, the LDP-IGP synchronization can be configured.

RTR1

(config)#interface xe11	Enter interface mode.
(config-if)#mpls ldp-igp sync ospf holddown-timer 500	<p>Enable LDP-IGP Synchronization for xe11 belonging to an OSPF process and 500 seconds is holddown-timer value for IGP to wait until LDP converges.</p> <p>OSPF: This command is part of OSPF Process.</p> <p>Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.</p>
(config-if)#mpls ldp-igp sync-delay 60	<p>Configure time delay in seconds for notification of LDP convergence to IGP. This is not applicable for notification of non-convergence. Range is 5 to 60 seconds. This command is optional.</p> <p>LDP: This command is part of LDP Process.</p> <p>Default: If not configured the delay is 0 seconds.</p>
(config-if)#commit	Commit the transaction.

RTR2

(config)#interface xe11	Enter interface mode.
(config-if)#mpls ldp-igp sync ospf holddown-timer 500	<p>Enable LDP-IGP Synchronization for interfaces (xe11) belonging to an OSPF process and 500 secs is Holddown-timer value for IGP to wait until LDP Converge.</p> <p>OSPF: This command is part of the OSPF Process. Note: Holddown-timer range is <1-2147483> seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use command mpls ldp-igp sync ospf to configure without a holddown-timer.</p>

(config-if)#mpls ldp-igp sync-delay 60	Configure the time delay in seconds for the notification of LDP convergence to IGP. (This is not applicable for notification of non-convergence.) Range is 5 to 60 seconds. This command is optional. LDP: This command is part of LDP Process. Default: If not configured the delay is 0 seconds.
(config-if)#commit	Commit the transaction.

RTR1 Validation

When LDP IGP SYNC is Configured with hold-down and sync-delay timer

```
R1#show ip ospf interface
lo is up, line protocol is up
  Internet Address 1.1.1.1/32, Area 0.0.0.0, MTU 16436
  Process ID 100, VRF (default), Router ID 1.1.1.1, Network Type LOOPBACK,
Cost:
  1
    Transmit Delay is 1 sec,  State Loopback, TE Metric 1
    Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
xe11 is up, line protocol is up
  Internet Address 10.10.10.1/24, Area 0.0.0.0, MTU 1500
  Process ID 100, VRF (default), Router ID 1.1.1.1, Network Type BROADCAST,
Cost
: 1
  Transmit Delay is 1 sec,  State Backup, Priority 1, TE Metric 1
LDP-OSPF Sync configured
  Holddown timer : 500 seconds, Remaining time = 0 seconds
  Designated Router (ID) 2.2.2.2, Interface Address 10.10.10.2
  Backup Designated Router (ID) 1.1.1.1, Interface Address 10.10.10.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
  Hello due in 00:00:06
  Neighbor Count is 1, Adjacent neighbor count is 1
  Hello received 178 sent 179, DD received 3 sent 6
  LS-Req received 1 sent 1, LS-Upd received 5 sent 6
  LS-Ack received 5 sent 4, Discarded 0
  No authentication

R1#show mpls ldp igp sync
xe11 is up, line protocol is up
LDP configured; LDP-IGP Synchronization enabled.
Session IP Address : 2.2.2.2
Sync status: Achieved
Delay timer: Configured, 60 seconds, Not Running
```

RTR2 Validation

```
R2#show ip ospf interface
lo is up, line protocol is up
  Internet Address 2.2.2.2/32, Area 0.0.0.0, MTU 16436
  Process ID 100, VRF (default), Router ID 2.2.2.2, Network Type LOOPBACK,
Cost:
  1
    Transmit Delay is 1 sec,  State Loopback, TE Metric 1
    Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
xe11 is up, line protocol is up
```

```

Internet Address 10.10.10.2/24, Area 0.0.0.0, MTU 1500
Process ID 100, VRF (default), Router ID 2.2.2.2, Network Type BROADCAST,
Cost
: 1
Transmit Delay is 1 sec, State DR, Priority 1, TE Metric 1
LDP-OSPF Sync configured
Holddown timer : 500 seconds, Remaining time = 0 seconds
Designated Router (ID) 2.2.2.2, Interface Address 10.10.10.2
Backup Designated Router (ID) 1.1.1.1, Interface Address 10.10.10.1
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:01
Neighbor Count is 1, Adjacent neighbor count is 1
Hello received 211 sent 211, DD received 6 sent 3
LS-Req received 1 sent 1, LS-Upd received 8 sent 7
LS-Ack received 6 sent 7, Discarded 0
No authentication

R2#show mpls ldp igp sync
xe11 is up, line protocol is up
LDP configured; LDP-IGP Synchronization enabled.
Session IP Address : 1.1.1.1
Sync status: Achieved
Delay timer: Configured, 60 seconds, Not Running

```

LDP-IGP Synchronization with IS-IS

When IGP synchronization is enabled on an IS-IS enabled interfaces, IS-IS sends Maximum/Normal cost based on LDP session or Up state on interfaces until hold-down-timer expires or synchronization is achieved.

Before configuring LDP-IGP synchronization, the NSM, IS-IS and LDP configurations must be completed. The tables below contain examples of how this is done.

RTR1 - NSM

#configure terminal	Enter configuration mode.
(config)#interface xe11	Enter interface mode.
(config-if)#ip address 10.10.10.1/24	Set the IP address of the xe11 to 10.10.10.1/24.
(config-if)#label-switching	Enable label switching on xe11.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
(config-if)#commit	Commit the transaction.

RTR1 - IS-IS

(config)#router isis 1	Configure the IS-IS routing instance and specify the TAG (1). The TAG should be a WORD - ISO routing area tag.
(config-router)#is-type level-1	Define the IS to the specified level of routing for router.
(config-router)#net 49.0001.0000.0000.0001.00	Configure the Network Entity Title (NET) for the instance.

(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe11	Enter interface mode.
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#isis circuit-type level-1	Define the circuit type for the interface on which IS-IS runs and associate the level 1.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode for the loopback interface (lo).
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#isis circuit-type level-1	Define the circuit type for the interface on which IS-IS runs and associate the level 1.
(config-if)#commit	Commit the transaction.

RTR1 - LDP

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1.
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address for IPV4 (for IPv6 use an IPv6 address) to use for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as transport address.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe11	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe11.
(config-if)#commit	Commit the transaction.

RTR2 - NSM

#configure terminal	Enter configuration mode
(config)#interface xe11	Enter interface mode.
(config-if)#ip address 10.10.10.2/24	Set the IP address of xe11 to 10.10.10.2/24
(config-if)#label-switching	Enable label switching on interface xe11.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if)#commit	Commit the transaction.

RTR2 - IS-IS

(config)#router isis 1	Configure the IS-IS routing instance and specify the TAG as 1. The TAG should be a WORD - ISO routing area tag.
(config-router)#is-type level-1	Define the IS to the specified level of routing for router.
(config-router)#net 49.0001.0000.0000.0002.00	Configure the Network Entity Title (NET) for the instance.

(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe11	Enter interface mode.
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with is-is tag instance 1.
(config-if)#isis circuit-type level-1	Define the circuit type for the interface on which IS-IS runs and associate the level type (1).
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode for the loopback (lo) interface.
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#isis circuit-type level-1	Define the circuit type for the interface on which IS-IS runs and associate the level 1.
(config-if)#commit	Commit the transaction.

RTR2 - LDP

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address for IPv4 (for IPv6 use an IPv6 address) to use for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as transport address.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe11	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe11.
(config-if)#commit	Commit the transaction.

Validation

```
R1#show clns neighbors
```

```
Total number of L1 adjacencies: 1
Total number of L2 adjacencies: 0
Total number of adjacencies: 1
Tag 1: VRF : default
```

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
0000.0000.0002	xe11	6cb9.c5cf.da69	Up	24	L1	IS-IS

```
R2#show clns neighbors
```

```
Total number of L1 adjacencies: 1
Total number of L2 adjacencies: 0
Total number of adjacencies: 1
Tag 1: VRF : default
```

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
0000.0000.0001	xe11	b86a.97d1.24d1	Up	9	L1	IS-IS

```
R1#show clns is-neighbors
```

```
Tag 1: VRF : default
System Id      Interface  State  Type  Priority  Circuit Id
0000.0000.0002 xell1     Up     L1    64      0000.0000.0001.01
```

```
R2#show clns is-neighbors
```

```
Tag 1: VRF : default
System Id      Interface  State  Type  Priority  Circuit Id
0000.0000.0001 xell1     Up     L1    64      0000.0000.0001.01
```

```
R1#show ldp session
```

```
Peer IP Address      IF Name      My Role      State          KeepAlive  UpTime
2.2.2.2              xell1        Passive      OPERATIONAL    30         00:08:08
```

```
R1#show ldp adjacency
```

```
Remote-Address  Local-Address  Mode      Intf-Name  Holdtime  LDP-Identifier
10.10.10.2      10.10.10.1    Interface xell1      15        2.2.2.2:0
```

```
R2#show ldp session
```

```
Peer IP Address      IF Name      My Role      State          KeepAlive  UpTime
1.1.1.1           xell1        Active       OPERATIONAL    30         00:08:24
```

```
R2#show ldp adjacency
```

```
Remote-Address  Local-Address  Mode      Intf-Name  Holdtime  LDP-Identifier
10.10.10.1      10.10.10.2    Interface xell1      15        1.1.1.1:0
```

```
R1#show isis interface xell1
```

```
xell1 is up, line protocol is up
```

```
Routing Protocol: IS-IS (1)
```

```
Network Type: Broadcast
```

```
Circuit Type: level-1
```

```
Local circuit ID: 0x01
```

```
Extended Local circuit ID: 0x0000271C
```

```
Local SNPA: b86a.97d1.24d1
```

```
IP interface address:
```

```
10.10.10.1/24
```

```
IPv6 interface address:
```

```
fe80::ba6a:97ff:fed1:24d1/64
```

```
Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0001.01
```

```
Number of active level-1 adjacencies: 1
```

```
Level-1 LSP MTU: 1492
```

```
Next IS-IS LAN Level-1 Hello in 792 milliseconds
```

```
R2#show isis interface xell1
```

```
xell1 is up, line protocol is up
```

```
Routing Protocol: IS-IS (1)
```

```
Network Type: Broadcast
```

```
Circuit Type: level-1
```

```
Local circuit ID: 0x01
```

```
Extended Local circuit ID: 0x0000271B
```

```
Local SNPA: 6cb9.c5cf.da69
```

```
IP interface address:
```

```
10.10.10.2/24
```

```
IPv6 interface address:
```

```
fe80::6eb9:c5ff:fecf:da69/64
```

```
Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0001.01
```

```
Number of active level-1 adjacencies: 1
```


Level-1 LSP MTU: 1492
 Next IS-IS LAN Level-1 Hello in 1 seconds

R1#show isis database detail

Tag 1: VRF : default

IS-IS Level-1 Link State Database:

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
0000.0000.0001.00-00*	0x00000002	0xB193	516	0/0/0
Area Address: 49.0001				
NLPID: 0xCC				
IP Address: 10.10.10.1				
Metric: 10	IS 0000.0000.0001.01			
Metric: 10	IP 10.10.10.0 255.255.255.0			
Metric: 10	IP 1.1.1.1 255.255.255.255			
0000.0000.0001.01-00*	0x00000001	0x1FBD	516	0/0/0
Metric: 0	IS 0000.0000.0001.00			
Metric: 0	IS 0000.0000.0002.00			
0000.0000.0002.00-00	0x00000002	0x84BA	519	0/0/0
Area Address: 49.0001				
NLPID: 0xCC				
IP Address: 10.10.10.2				
Metric: 10	IS 0000.0000.0001.01			
Metric: 10	IP 10.10.10.0 255.255.255.0			
Metric: 10	IP 2.2.2.2 255.255.255.255			

R2#show isis database detail

Tag 1: VRF : default

IS-IS Level-1 Link State Database:

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
0000.0000.0001.00-00	0x00000002	0xB193	521	0/0/0
Area Address: 49.0001				
NLPID: 0xCC				
IP Address: 10.10.10.1				
Metric: 10	IS 0000.0000.0001.01			
Metric: 10	IP 10.10.10.0 255.255.255.0			
Metric: 10	IP 1.1.1.1 255.255.255.255			
0000.0000.0001.01-00	0x00000001	0x1FBD	521	0/0/0
Metric: 0	IS 0000.0000.0001.00			
Metric: 0	IS 0000.0000.0002.00			
0000.0000.0002.00-00*	0x00000002	0x84BA	526	0/0/0
Area Address: 49.0001				
NLPID: 0xCC				
IP Address: 10.10.10.2				
Metric: 10	IS 0000.0000.0001.01			
Metric: 10	IP 10.10.10.0 255.255.255.0			
Metric: 10	IP 2.2.2.2 255.255.255.255			

LDP-IGP SYNC Configuration

Now that NSM, IS-IS and LDP are all enabled, the LDP-IGP synchronization can be configured.

RTR1

(config)#interface xe11	Enter interface mode.
(config-if)#mpls ldp-igp sync isis level-1 holddown-timer 700	<p>Configure LDP-IGP Synchronization for interface xe11 belonging to an IS-IS process with corresponding IS-IS level. 700 seconds is the holddown-timer value for IGP to wait until LDP converges.</p> <p>The values level-1 level-2-only level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command.</p> <p>IS-IS: This command is part of ISIS Process.</p> <p>Default: Mandatory configuration. No default option.</p> <p>Note: The holddown-timer Range is 1 to 2147483 seconds. If no holddown timer is configured, IGP waits indefinitely for LDP to Converge. Use the command mpls ldp-igp sync is-is <level-type> to configure without a holddown-timer.</p>
(config-if)#mpls ldp-igp sync-delay 55	<p>Set the time delay in seconds for the notification of LDP convergence to IGP. This is not applicable for notification of non-convergence. Range is 5 to 60 seconds. This command is optional.</p> <p>LDP: This command is part of LDP Process.</p> <p>Default: If not configured, the delay is 0 seconds.</p>
(config-if)#commit	Commit the transaction.

LDP-IGP SYNC Configuration

Now that NSM, IS-IS and LDP are all enabled, the LDP-IGP synchronization can be configured.

RTR2

(config)#interface xe11	Enter interface mode.
(config-if)#mpls ldp-igp sync isis level-1 holddown-timer 700	<p>Configure LDP-IGP Synchronization for interface xe11 belonging to an IS-IS process with corresponding IS-IS level. 700 secs is the holddown-timer value for IGP to wait until LDP converges.</p> <p>The parameters level-1 level-2-only level-1-2 identify the IS-IS instance level. The interface can be acting on any level, but sync is applicable only when it matches with the level given in IGP sync command.</p> <p>IS-IS: This command is part of IS-IS Process.</p> <p>Default: Mandatory configuration. No default option.</p> <p>Note: The holddown-timer Range is 1 to 2147483 seconds. If no holddown timer is configured, IGP waits indefinitely for LDP to Converge. Use command mpls ldp-igp sync is-is <level-type> to configure without a holddown-timer.</p>

(config-if)#mpls ldp-igp sync-delay 55	Set the time delay in seconds for notification of LDP convergence to IGP. This is not applicable for notification of non-convergence. Range is 5 to 60 seconds. This command is optional. LDP: This command is part of LDP Process. Default: If not configured, the delay is 0 seconds.
(config-if)#commit	Commit the transaction.

RTR1 Validation

When LDP IGP SYNC is Configured with hold-down and sync-delay timer

```
R1#show isis interface xell
xell is up, line protocol is up
  Routing Protocol: IS-IS (1)
    Network Type: Broadcast
    Circuit Type: level-1
    Local circuit ID: 0x01
    Extended Local circuit ID: 0x0000271C
    Local SNPA: b86a.97d1.24d1
    IP interface address:
      10.10.10.1/24
    IPv6 interface address:
      fe80::ba6a:97ff:fed1:24d1/64
LDP-ISIS Sync Configured
  Holddown timer = 700 seconds, Remaining time = 0 seconds
Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0001.01
  Number of active level-1 adjacencies: 1
  Level-1 LSP MTU: 1492
  Next IS-IS LAN Level-1 Hello in 420 milliseconds

R1#show mpls ldp igp sync
xell is up, line protocol is up
LDP configured; LDP-IGP Synchronization enabled.
Session IP Address : 2.2.2.2
Sync status: Achieved
Delay timer: Configured, 55 seconds, Not Running

R1#
```

RTR2 Validation

```
R2#show isis interface xell
xell is up, line protocol is up
  Routing Protocol: IS-IS (1)
    Network Type: Broadcast
    Circuit Type: level-1
    Local circuit ID: 0x01
    Extended Local circuit ID: 0x0000271B
    Local SNPA: 6cb9.c5cf.da69
    IP interface address:
      10.10.10.2/24
    IPv6 interface address:
      fe80::6eb9:c5ff:fecf:da69/64
LDP-ISIS Sync Configured
  Holddown timer = 700 seconds, Remaining time = 0 seconds
```

Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0001.01
Number of active level-1 adjacencies: 1
Level-1 LSP MTU: 1492
Next IS-IS LAN Level-1 Hello in 4 seconds

```
R2#show mpls ldp igp sync
xe11 is up, line protocol is up
  LDP configured; LDP-IGP Synchronization enabled.
  Session IP Address : 1.1.1.1
  Sync status: Achieved
  Delay timer: Configured, 55 seconds, Not Running
```

CHAPTER 4 LDP-FRR Configuration

LDP Fast Re-route (FRR) is a technology which helps the router to reduce the MPLS traffic loss in cases of convergence during network failure. A router's convergence time is in general in the order of hundreds of milliseconds, but some applications may be very sensitive to data-loss. This technology helps the router to minimize the MPLS traffic loss by calculating and installing alternate backup paths prior to failure.

LDP FRR improves convergence in case of a single link or single node failure in the network. Convergence times will be in the order of 10s of milliseconds (Max convergence - 50 milliseconds). This is important to some application services (like VoIP) which are sensitive to traffic loss when running over the MPLS network.

Without FRR, link and/or node failures inside an MPLS LDP network result in traffic loss in the order of 100s of milliseconds. The reason for that is that LDP depends on the convergence of the underlying IGP (IS-IS sending LSPs/ OSPF sending LSAs in this case). Post IGP convergence, LDP itself needs to compute new primary Next-Hop Label Forwarding Entries (NHLFEs) for all affected Forwarding Equivalence Classes (FECs). Finally, the different Label Forwarding Information Bases (LFIBs) are updated.

When FRR is configured on a node, the node pre-computes primary NHLFEs for all FECs and in addition it will pre-compute backup NHLFEs for all FECs. The backup NHLFE corresponds to the label received for the same FEC from a Loop-Free Alternate (LFA) next-hop.

Note: This implementation requires either ISIS LFA or OSPF LFA and LDP IGP synchronization.

Topology

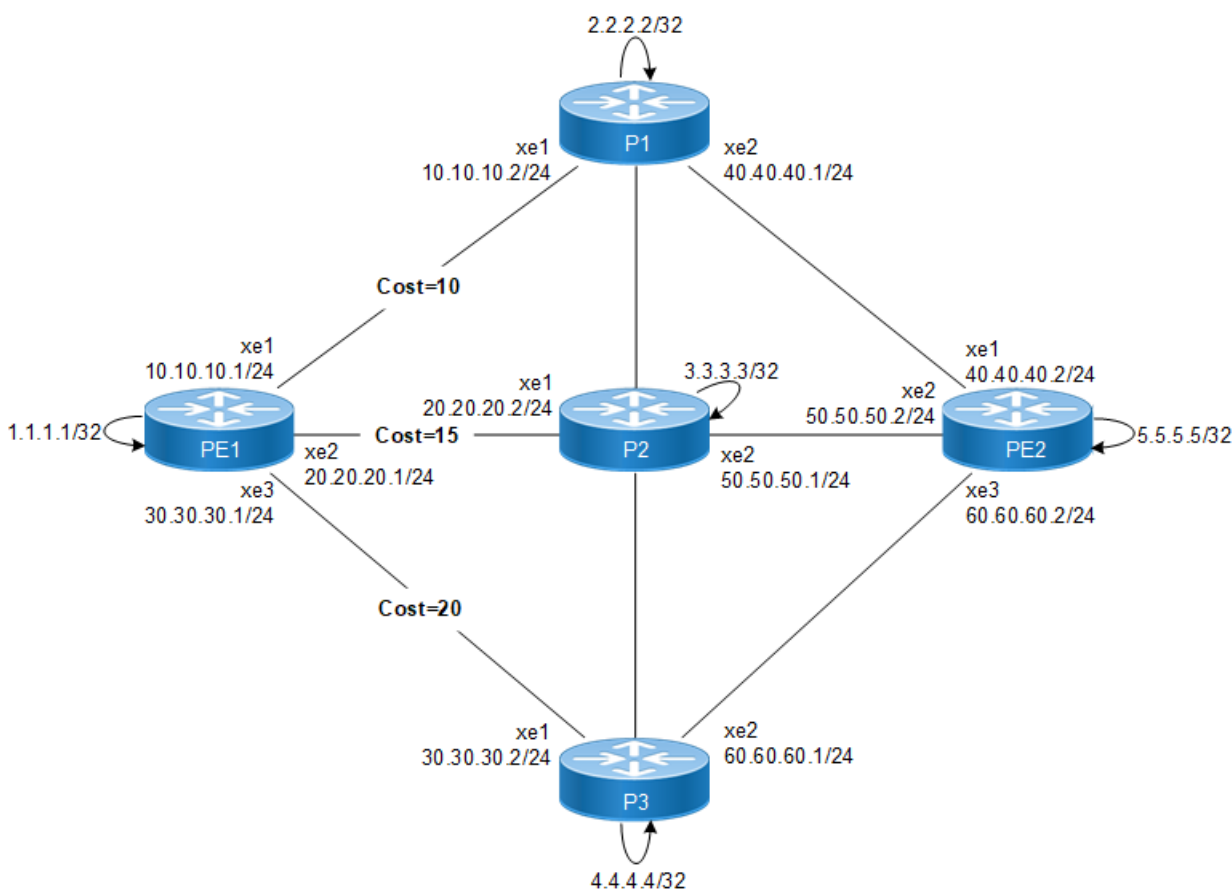


Figure 4-3: LDP-FRR Topology

LDP-FRR with OSPF as IGP Configuration

Below are the configurations and validations involving NSM, OSPF, LDP before configuring fast-reroute for IGP and LDP

PE1

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1
(config-router)#transport-address ipv4 1.1.1.1 0	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 5.5.5.5	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.10.10.1/24	Configure IPv4 address for xe1.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe1.
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#mpls ldp-igp sync ospf holddown-timer 500	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 20.20.20.1/24	Configure IPv4 address for xe2
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe2.
(config-if)#ip ospf cost 15	Assign ospf cost to the interface

(config-if)#mpls ldp-igp sync ospf holddown-timer 500	<p>Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges.</p> <p>OSPF: This command is part of OSPF Process.</p> <p>Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.</p>
(config-if)#exit	Exit interface mode
(config)#interface xe3	Enter interface mode.
(config-if)#ip address 30.30.30.1/24	Configure IPv4 address for xe3
(config-if)#label-switching	Enable label switching on interface xe3
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe3
(config-if)#ip ospf cost 20	Assign OSPF cost to the interface
(config-if)#mpls ldp-igp sync ospf holddown-timer 500	<p>Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges.</p> <p>OSPF: This command is part of OSPF Process.</p> <p>Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync OSPF to configure without a holddown-timer.</p>
(config-if)#exit	Exit interface mode
(config)#router ospf 1	Configure the routing process and specify the Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
(config)#ospf router-id 1.1.1.1	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 1.1.1.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.10.10.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 20.20.20.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 30.30.30.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-if)#exit	Exit interface mode.
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#commit	Commit all the configurations

P1

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2
(config-router)#transport-address ipv4 2.2.2.2 0	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.10.10.2/24	Configure IPv4 address for xe1.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe1.
(config-if)#mpls ldp-igp sync ospf holddown- timer 500	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 40.40.40.1/24	Configure IPv4 address for xe2
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe2.
(config-if)#mpls ldp-igp sync ospf holddown- timer 500	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
(config-if)#exit	Exit interface mode
(config)#router ospf 1	Configure the routing process and specify the Process ID <ul style="list-style-type: none"> The Process ID should be a unique positive integer identifying the routing process.

(config)#ospf router-id 2.2.2.2	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
(config-router)#network 10.10.10.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
(config-router)#network 40.40.40.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-if)#exit	Exit interface mode.
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#commit	Commit all the configurations

P2

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 3.3.3.3	Set the router ID to IP address 3.3.3.3
(config-router)#transport-address ipv4 3.3.3.3 0	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 20.20.20.2/24	Configure IPv4 address for xe1.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe1.
(config-if)#mpls ldp-igp sync ospf holddown-timer 500	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 50.50.50.1/24	Configure IPv4 address for xe2
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe2.

(config-if)#mpls ldp-igp sync ospf holddown-timer 500	<p>Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges.</p> <p>OSPF: This command is part of OSPF Process.</p> <p>Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.</p>
(config-if)#exit	Exit interface mode
(config)#router ospf 1	<p>Configure the routing process and specify the Process ID</p> <ul style="list-style-type: none"> The Process ID should be a unique positive integer identifying the routing process.
(config)#ospf router-id 3.3.3.3	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 3.3.3.3/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
(config-router)#network 20.20.20.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
(config-router)#network 50.50.50.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-if)#exit	Exit interface mode.
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#commit	Commit all the configurations

P3

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 4.4.4.4/32 secondary	Set the IP address of the loopback interface
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 4.4.4.4	Set the router ID to IP address 4.4.4.4
(config-router)#transport-address ipv4 4.4.4.4 0	<p>Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run.</p> <p>Note: It is preferable to use the loopback address as the transport address.</p>
(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 30.30.30.2/24	Configure IPv4 address for xe1.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe1.

(config-if)#mpls ldp-igp sync ospf holddown-timer 500	<p>Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges.</p> <p>OSPF: This command is part of OSPF Process.</p> <p>Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.</p>
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 60.60.60.1/24	Configure IPv4 address for xe2
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe2.
(config-if)#mpls ldp-igp sync ospf holddown-timer 500	<p>Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges.</p> <p>OSPF: This command is part of OSPF Process.</p> <p>Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.</p>
(config-if)#exit	Exit interface mode
(config)#router ospf 1	<p>Configure the routing process and specify the Process ID</p> <ul style="list-style-type: none"> The Process ID should be a unique positive integer identifying the routing process.
(config)#ospf router-id 4.4.4.4	Configure OSPF router-ID same as loopback interface IP address.
(config-router)#network 4.4.4.4/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 30.30.30.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 60.60.60.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-if)#exit	Exit interface mode.
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#commit	Commit all the configurations

PE2

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 5.5.5.5/32 secondary	Set the IP address of the loopback interface to 5.5.5.5/32
(config-if)#exit	Exit interface mode.

(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 5.5.5.5	Set the router ID to IP address 5.5.5.5
(config-router)#transport-address ipv4 5.5.5.5 0	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 40.40.40.2/24	Configure IPv4 address for xe1.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe1.
(config-if)#mpls ldp-igp sync ospf holddown-timer 500	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 50.50.50.2/24	Configure IPv4 address for xe2
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe2.
(config-if)#mpls ldp-igp sync ospf holddown-timer 500	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
(config-if)#exit	Exit interface mode
(config)#interface xe3	Enter interface mode.
(config-if)#ip address 60.60.60.2/24	Configure IPv4 address for xe3
(config-if)#label-switching	Enable label switching on interface xe3
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe3

(config-if)#mpls ldp-igp sync ospf holddown-timer 500	<p>Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges.</p> <p>OSPF: This command is part of OSPF Process.</p> <p>Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.</p>
(config-if)#exit	Exit interface mode
(config)#router ospf 1	<p>Configure the routing process and specify the Process ID</p> <ul style="list-style-type: none"> The Process ID should be a unique positive integer identifying the routing process.
(config)#ospf router-id 5.5.5.5	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 5.5.5.5/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 40.40.40.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 50.50.50.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 60.60.60.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-if)#exit	Exit interface mode.
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#commit	Commit all the configurations

Validation

PE1

```
PE1#show ip ospf neighbor
```

Total number of full neighbors: 3

OSPF process 1 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
2.2.2.2	1	Full/Backup	00:00:31	10.10.10.2	xe1	0
3.3.3.3	1	Full/Backup	00:00:32	20.20.20.2	xe2	0
4.4.4.4	1	Full/Backup	00:00:33	30.30.30.2	xe3	0

```
PE1#show ip ospf interface brief
```

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
lo	1	0.0.0.0	1	1	Loopback	0	Up
xe1	1	0.0.0.0	4	10	DR	1	Up

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
xe2	1	0.0.0.0	14	15	DR	1	Up

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
xe3	1	0.0.0.0	15	20	DR	1	Up

PE1#show ip ospf database

OSPF Router with ID (1.1.1.1) (Process ID 1 VRF default)

Router Link States (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum	Link count
1.1.1.1	1.1.1.1	66	0x8000000e	0x5cf2	4
2.2.2.2	2.2.2.2	48	0x80000008	0x615f	3
3.3.3.3	3.3.3.3	48	0x80000008	0x64d7	3
4.4.4.4	4.4.4.4	44	0x80000008	0x6750	3
5.5.5.5	5.5.5.5	47	0x80000004	0xd65b	4

Net Link States (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum
10.10.10.1	1.1.1.1	249	0x80000001	0x9476
20.20.20.1	1.1.1.1	152	0x80000001	0x5d8b
30.30.30.1	1.1.1.1	106	0x80000001	0x26a0
40.40.40.1	2.2.2.2	55	0x80000001	0xf2a9
50.50.50.1	3.3.3.3	53	0x80000001	0x8de8
60.60.60.1	4.4.4.4	50	0x80000001	0x2828

Area-Local Opaque-LSA (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum	Opaque ID
1.0.0.1	1.1.1.1	150	0x80000003	0x2cf8	1
1.0.0.1	2.2.2.2	54	0x80000002	0x32eb	1
1.0.0.1	3.3.3.3	51	0x80000003	0x34e0	1
1.0.0.1	4.4.4.4	48	0x80000003	0x38d4	1
1.0.0.1	5.5.5.5	54	0x80000001	0x40c6	1
1.0.0.8	4.4.4.4	48	0x80000001	0x7b37	8
1.0.0.8	5.5.5.5	49	0x80000001	0x7b32	8
1.0.0.10	1.1.1.1	236	0x80000002	0xda05	10
1.0.0.10	2.2.2.2	237	0x80000002	0x8360	10
1.0.0.12	3.3.3.3	46	0x80000002	0xc924	12
1.0.0.12	5.5.5.5	49	0x80000002	0xab39	12
1.0.0.22	2.2.2.2	46	0x80000002	0xdd46	22
1.0.0.22	5.5.5.5	47	0x80000002	0xa175	22
1.0.0.30	1.1.1.1	109	0x80000002	0x7614	30
1.0.0.30	3.3.3.3	110	0x80000002	0x424d	30
1.0.0.32	1.1.1.1	64	0x80000002	0xc680	32
1.0.0.32	4.4.4.4	65	0x80000002	0xb597	32

```
PE1#show ip route summary
```

```
-----
IP routing table name is Default-IP-Routing-Table(0)
-----
```

```
IP routing table maximum-paths      : 8
Total number of IPv4 routes         : 14
Total number of IPv4 paths          : 14
Pending routes (due to route max reached): 0
Route Source      Networks
kernel            1
connected         6
ospf              7
Total             14
FIB               14
```

```
ECMP statistics (active in ASIC):
```

```
Total number of IPv4 ECMP routes : 0
Total number of IPv4 ECMP paths  : 0
```

```
PE1#show ip interface brief
```

```
'*' - address is assigned by dhcp client
```

Interface	IP-Address	Admin-Status	Link-Status
xe0	*10.12.49.172	up	up
xe1	unassigned	up	up
xe1	10.10.10.1	up	up
xe3	unassigned	up	up
xe4	unassigned	up	up
xe5	unassigned	up	up
xe6	unassigned	up	up
xe7	unassigned	up	up
xe8	unassigned	up	up
xe9	unassigned	up	up
xe10	unassigned	up	up
xe11	unassigned	up	up
xe2	20.20.20.1	up	up
xe3	30.30.30.1	up	up
lo	127.0.0.1	up	up

```
PE1#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
5.5.5.5	xe2	Passive	OPERATIONAL	30	00:01:06
2.2.2.2	xe1	Passive	OPERATIONAL	30	00:04:34
3.3.3.3	xe2	Passive	OPERATIONAL	30	00:02:28
4.4.4.4	xe3	Passive	OPERATIONAL	30	00:01:43

```
PE1#show ip route
```

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
 O - OSPF, IA - OSPF inter area
 N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
 E1 - OSPF external type 1, E2 - OSPF external type 2
 i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
 ia - IS-IS inter area, E - EVPN,
 v - vrf leaked
 * - candidate default

IP Route Table for VRF "default"

Gateway of last resort is 10.12.49.1 to network 0.0.0.0

```
K*      0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C       1.1.1.1/32 is directly connected, lo, 00:10:42
O       2.2.2.2/32 [110/11] via 10.10.10.2, xe1, 00:04:54
O       3.3.3.3/32 [110/13] via 10.10.10.2, xe1, 00:01:41
O       4.4.4.4/32 [110/13] via 10.10.10.2, xe1, 00:01:41
O       5.5.5.5/32 [110/12] via 10.10.10.2, xe1, 00:01:43
C       10.10.10.0/24 is directly connected, xe1, 00:08:51
C       10.12.49.0/24 is directly connected, xe0, 16:20:51
C       20.20.20.0/24 is directly connected, xe2, 00:08:51
C       30.30.30.0/24 is directly connected, xe3, 00:08:51
O       40.40.40.0/24 [110/11] via 10.10.10.2, xe1, 00:01:43
O       50.50.50.0/24 [110/12] via 10.10.10.2, xe1, 00:01:41
O       60.60.60.0/24 [110/12] via 10.10.10.2, xe1, 00:01:41
C       127.0.0.0/8 is directly connected, lo, 16:34:27
```

PE1#show ldp routes

Prefix	Addr	Nexthop	Addr	Intf	Owner
0.0.0.0/0		10.12.49.1		xe0	kernel
1.1.1.1/32		0.0.0.0		lo	connected
2.2.2.2/32		10.10.10.2		xe1	ospf
3.3.3.3/32		10.10.10.2		xe1	ospf
4.4.4.4/32		10.10.10.2		xe1	ospf
5.5.5.5/32		10.10.10.2		xe1	ospf
10.10.10.0/24		0.0.0.0		xe1	connected
10.12.49.0/24		0.0.0.0		xe0	connected
20.20.20.0/24		0.0.0.0		xe2	connected
30.30.30.0/24		0.0.0.0		xe3	connected
40.40.40.0/24		10.10.10.2		xe1	ospf
50.50.50.0/24		10.10.10.2		xe1	ospf
60.60.60.0/24		10.10.10.2		xe1	ospf

PE1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
L>	2.2.2.2/32	1	1	-	Yes	LSP_DEFAULT	3	xe1	No	10.10.10.2
L>	3.3.3.3/32	3	9	-	Yes	LSP_DEFAULT	25601	xe1	No	10.10.10.2
L>	4.4.4.4/32	5	10	-	Yes	LSP_DEFAULT	25602	xe1	No	10.10.10.2
L>	5.5.5.5/32	7	7	-	Yes	LSP_DEFAULT	25600	xe1	No	10.10.10.2

L>	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
L>	40.40.40.0/24	2	1	-	Yes	LSP_DEFAULT	3	xel	No	10.10.10.2
L>	50.50.50.0/24	4	11	-	Yes	LSP_DEFAULT	25612	xel	No	10.10.10.2
L>	60.60.60.0/24	6	8	-	Yes	LSP_DEFAULT	25609	xel	No	10.10.10.2

PE1#show mpls forwarding-table 5.5.5.5/32

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
L>	5.5.5.5/32	7	7	-	Yes	LSP_DEFAULT	25600	xel	No	10.10.10.2

PE1#show ldp fec

LSR codes : E/N - LSR is egress/non-egress for this FEC,

L - LSR received a label for this FEC,

> - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	E >	non-existent	none	No	connected
2.2.2.2/32	NL	4.4.4.4	25608	No	no nexthop
	NL	3.3.3.3	25607	No	no nexthop
	NL>	2.2.2.2	impl-null	No	10.10.10.2
3.3.3.3/32	NL	4.4.4.4	25609	No	no nexthop
	NL>	2.2.2.2	25601	No	10.10.10.2
	NL	3.3.3.3	impl-null	No	no nexthop
4.4.4.4/32	NL	3.3.3.3	25608	No	no nexthop
	NL>	2.2.2.2	25602	No	10.10.10.2
	NL	4.4.4.4	impl-null	No	no nexthop
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NL>	2.2.2.2	25600	No	10.10.10.2
	NL	3.3.3.3	25600	No	no nexthop
10.10.10.0/24	NL	4.4.4.4	25611	No	connected
	NL	3.3.3.3	25610	No	connected
	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
10.12.49.0/24	NL	4.4.4.4	impl-null	No	connected
	NL	3.3.3.3	impl-null	No	connected
	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
20.20.20.0/24	NL	4.4.4.4	25612	No	connected
	NL	2.2.2.2	25610	No	connected
	NL	3.3.3.3	impl-null	No	connected
	E >	non-existent	none	No	connected
30.30.30.0/24	NL	3.3.3.3	25611	No	connected
	NL	2.2.2.2	25611	No	connected
	NL	4.4.4.4	impl-null	No	connected
	E >	non-existent	none	No	connected
40.40.40.0/24	NL	4.4.4.4	25613	No	no nexthop
	NL	3.3.3.3	25612	No	no nexthop
	NL>	2.2.2.2	impl-null	No	10.10.10.2
50.50.50.0/24	NL	4.4.4.4	25614	No	no nexthop
	NL>	2.2.2.2	25612	No	10.10.10.2
	NL	3.3.3.3	impl-null	No	no nexthop
60.60.60.0/24	NL>	2.2.2.2	25609	No	10.10.10.2

NL	3.3.3.3	25609	No	no nexthop
NL	4.4.4.4	impl-null	No	no nexthop

PE1#show ldp downstream

gSession peer 5.5.5.5:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
-----	--------------	-------	-------	--------	------

Session peer 2.2.2.2:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
50.50.50.0/24	10.10.10.2	Established	25612	0	
30.30.30.0/24	connected	Established	25611	0	
20.20.20.0/24	connected	Established	25610	0	
4.4.4.4/32	10.10.10.2	Established	25602	0	
3.3.3.3/32	10.10.10.2	Established	25601	0	
60.60.60.0/24	10.10.10.2	Established	25609	0	
5.5.5.5/32	10.10.10.2	Established	25600	0	
40.40.40.0/24	10.10.10.2	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.10.10.0/24	connected	Established	impl-null	0	
2.2.2.2/32	10.10.10.2	Established	impl-null	0	

Session peer 3.3.3.3:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
40.40.40.0/24	connected	Established	25612	0	
30.30.30.0/24	connected	Established	25611	0	
10.10.10.0/24	connected	Established	25610	0	
4.4.4.4/32	connected	Established	25608	0	
2.2.2.2/32	connected	Established	25607	0	
60.60.60.0/24	connected	Established	25609	0	
5.5.5.5/32	connected	Established	25600	0	
50.50.50.0/24	connected	Established	impl-null	0	
20.20.20.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
3.3.3.3/32	connected	Established	impl-null	0	

Session peer 4.4.4.4:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
50.50.50.0/24	connected	Established	25614	0	
40.40.40.0/24	connected	Established	25613	0	
20.20.20.0/24	connected	Established	25612	0	
10.10.10.0/24	connected	Established	25611	0	
5.5.5.5/32	connected	Established	25610	0	
3.3.3.3/32	connected	Established	25609	0	
2.2.2.2/32	connected	Established	25608	0	
60.60.60.0/24	connected	Established	impl-null	0	
30.30.30.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
4.4.4.4/32	connected	Established	impl-null	0	

PE1#show ldp lsp

DOWNSTREAM LSP :

FEC	Nexthop Addr	State	Label	Req.ID	Attr
1.1.1.1/32	connected	Established	none	0	None

2.2.2.2/32	connected	Established	25608	0	
2.2.2.2/32	connected	Established	25607	0	
2.2.2.2/32	10.10.10.2	Established	impl-null	0	
3.3.3.3/32	connected	Established	25609	0	
3.3.3.3/32	10.10.10.2	Established	25601	0	
3.3.3.3/32	connected	Established	impl-null	0	
4.4.4.4/32	connected	Established	25608	0	
4.4.4.4/32	10.10.10.2	Established	25602	0	
4.4.4.4/32	connected	Established	impl-null	0	
5.5.5.5/32	connected	Established	25610	0	
5.5.5.5/32	10.10.10.2	Established	25600	0	
5.5.5.5/32	connected	Established	25600	0	
10.10.10.0/24	connected	Established	25611	0	
10.10.10.0/24	connected	Established	25610	0	
10.10.10.0/24	connected	Established	impl-null	0	
10.10.10.0/24	connected	Established	none	0	None
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	none	0	None
20.20.20.0/24	connected	Established	25612	0	
20.20.20.0/24	connected	Established	25610	0	
20.20.20.0/24	connected	Established	impl-null	0	
20.20.20.0/24	connected	Established	none	0	None
30.30.30.0/24	connected	Established	25611	0	
30.30.30.0/24	connected	Established	25611	0	
30.30.30.0/24	connected	Established	impl-null	0	
30.30.30.0/24	connected	Established	none	0	None
40.40.40.0/24	connected	Established	25613	0	
40.40.40.0/24	connected	Established	25612	0	
40.40.40.0/24	10.10.10.2	Established	impl-null	0	
50.50.50.0/24	connected	Established	25614	0	
50.50.50.0/24	10.10.10.2	Established	25612	0	
50.50.50.0/24	connected	Established	impl-null	0	
60.60.60.0/24	10.10.10.2	Established	25609	0	
60.60.60.0/24	connected	Established	25609	0	
60.60.60.0/24	connected	Established	impl-null	0	

UPSTREAM LSP :

FEC	State	Label	Req.ID	Attr
1.1.1.1/32	Established	impl-null	0	None
1.1.1.1/32	Established	impl-null	0	None
1.1.1.1/32	Established	impl-null	0	None
2.2.2.2/32	Established	25602	0	None
2.2.2.2/32	Established	25608	0	None
3.3.3.3/32	Established	25614	0	None
3.3.3.3/32	Established	25609	0	None
3.3.3.3/32	Established	25609	0	None
4.4.4.4/32	Established	25605	0	None
4.4.4.4/32	Established	25615	0	None

4.4.4.4/32	Established	25605	0	None
5.5.5.5/32	Established	25606	0	None
5.5.5.5/32	Established	25613	0	None
5.5.5.5/32	Established	25613	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
40.40.40.0/24	Established	25603	0	None
40.40.40.0/24	Established	25610	0	None
50.50.50.0/24	Established	25616	0	None
50.50.50.0/24	Established	25611	0	None
50.50.50.0/24	Established	25611	0	None
60.60.60.0/24	Established	25607	0	None
60.60.60.0/24	Established	25612	0	None
60.60.60.0/24	Established	25612	0	None
60.60.60.0/24	Established	25607	0	None

PE1#show ldp lsp

DOWNSTREAM LSP :

FEC	Nexthop Addr	State	Label	Req.ID	Attr
1.1.1.1/32	connected	Established	none	0	None
2.2.2.2/32	connected	Established	25608	0	
2.2.2.2/32	connected	Established	25607	0	
2.2.2.2/32	10.10.10.2	Established	impl-null	0	
3.3.3.3/32	connected	Established	25609	0	
3.3.3.3/32	10.10.10.2	Established	25601	0	
3.3.3.3/32	connected	Established	impl-null	0	
4.4.4.4/32	connected	Established	25608	0	
4.4.4.4/32	10.10.10.2	Established	25602	0	
4.4.4.4/32	connected	Established	impl-null	0	
5.5.5.5/32	connected	Established	25610	0	
5.5.5.5/32	10.10.10.2	Established	25600	0	
5.5.5.5/32	connected	Established	25600	0	
10.10.10.0/24	connected	Established	25611	0	
10.10.10.0/24	connected	Established	25610	0	
10.10.10.0/24	connected	Established	impl-null	0	
10.10.10.0/24	connected	Established	none	0	None
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	none	0	None

20.20.20.0/24	connected	Established	25612	0	
20.20.20.0/24	connected	Established	25610	0	
20.20.20.0/24	connected	Established	impl-null	0	
20.20.20.0/24	connected	Established	none	0	None
30.30.30.0/24	connected	Established	25611	0	
30.30.30.0/24	connected	Established	25611	0	
30.30.30.0/24	connected	Established	impl-null	0	
30.30.30.0/24	connected	Established	none	0	None
40.40.40.0/24	connected	Established	25613	0	
40.40.40.0/24	connected	Established	25612	0	
40.40.40.0/24	10.10.10.2	Established	impl-null	0	
50.50.50.0/24	connected	Established	25614	0	
50.50.50.0/24	10.10.10.2	Established	25612	0	
50.50.50.0/24	connected	Established	impl-null	0	
60.60.60.0/24	10.10.10.2	Established	25609	0	
60.60.60.0/24	connected	Established	25609	0	
60.60.60.0/24	connected	Established	impl-null	0	

UPSTREAM LSP :

FEC	State	Label	Req.ID	Attr
1.1.1.1/32	Established	impl-null	0	None
1.1.1.1/32	Established	impl-null	0	None
1.1.1.1/32	Established	impl-null	0	None
2.2.2.2/32	Established	25602	0	None
2.2.2.2/32	Established	25608	0	None
3.3.3.3/32	Established	25614	0	None
3.3.3.3/32	Established	25609	0	None
3.3.3.3/32	Established	25609	0	None
4.4.4.4/32	Established	25605	0	None
4.4.4.4/32	Established	25615	0	None
4.4.4.4/32	Established	25605	0	None
5.5.5.5/32	Established	25606	0	None
5.5.5.5/32	Established	25613	0	None
5.5.5.5/32	Established	25613	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
40.40.40.0/24	Established	25603	0	None
40.40.40.0/24	Established	25610	0	None
50.50.50.0/24	Established	25616	0	None
50.50.50.0/24	Established	25611	0	None

50.50.50.0/24	Established	25611	0	None
60.60.60.0/24	Established	25607	0	None
60.60.60.0/24	Established	25612	0	None
60.60.60.0/24	Established	25612	0	None
60.60.60.0/24	Established	25607	0	None

PE1#show ldp fec prefix 5.5.5.5/32

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NL>	2.2.2.2	25600	No	10.10.10.2
	NL	3.3.3.3	25600	No	no nexthop

PE1#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
 Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
 Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
 Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
 Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
 Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
 Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 9
 Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25601
 Nexthop addr: 10.10.10.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 5, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
 Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
 Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 10
 Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 10, owner: LDP, Stale: NO, out intf: xe1, out label: 25602
 Nexthop addr: 10.10.10.2 cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A

```
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:391, pkts:5, TX bytes:411, Pushed pkts:5
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
Nexthop addr: 10.10.10.2          cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 10.10.10.2          cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 50.50.50.0/24, id: 4, row status: Active, Tunnel-Policy: N/
A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 11
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25612
Nexthop addr: 10.10.10.2          cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 60.60.60.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609
Nexthop addr: 10.10.10.2          cross connect ix: 8, op code: Push

PE1#show mpls ftn-table 5.5.5.5/32
Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:391, pkts:5, TX bytes:411, Pushed pkts:5
```

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
 Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
 Nexthop addr: 10.10.10.2 cross connect ix: 2, op code: Push

PE1#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup

K - CLI ILM, T - MPLS-TP, s - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

Code Type	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF	Nexthop	pri	LSP-
L>	2.2.2.2/32	9	25608	3	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
L>	4.4.4.4/32	6	25605	25602	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
L>	2.2.2.2/32	3	25602	3	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
L>	40.40.40.0/24	4	25603	3	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
L>	5.5.5.5/32	7	25606	25600	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
L>	60.60.60.0/24	8	25607	25609	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
L>	60.60.60.0/24	13	25612	25609	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
LSP_DEFAULT									
L>	40.40.40.0/24	11	25610	3	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
L>	3.3.3.3/32	10	25609	25601	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
L>	50.50.50.0/24	12	25611	25612	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
LSP_DEFAULT									
L>	3.3.3.3/32	15	25614	25601	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
L>	5.5.5.5/32	14	25613	25600	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
L>	4.4.4.4/32	16	25615	25602	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
L>	50.50.50.0/24	17	25616	25612	N/A	xe1	10.10.10.2	Yes	LSP_DEFAULT
LSP_DEFAULT									

PE2

PE2#show ip ospf neighbor

Total number of full neighbors: 3

OSPF process 1 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface	
2.2.2.2	1	Full/DR	00:00:36	40.40.40.1	xe1	0
3.3.3.3	1	Full/DR	00:00:37	50.50.50.1	xe2	0
4.4.4.4	1	Full/DR	00:00:31	60.60.60.1	xe3	0

PE2#show ip ospf interface brief

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
lo	1	0.0.0.0	1	1	Loopback	0	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
xe3	1	0.0.0.0	3	1	Backup	1	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
xe2	1	0.0.0.0	5	1	Backup	1	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
xe1	1	0.0.0.0	10	1	Backup	1	Up

PE2#show ip ospf database

OSPF Router with ID (5.5.5.5) (Process ID 1 VRF default)

Router Link States (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum	Link count
1.1.1.1	1.1.1.1	650	0x8000000e	0x5cf2	4
2.2.2.2	2.2.2.2	630	0x80000008	0x615f	3
3.3.3.3	3.3.3.3	631	0x80000008	0x64d7	3
4.4.4.4	4.4.4.4	627	0x80000008	0x6750	3
5.5.5.5	5.5.5.5	628	0x80000004	0xd65b	4

Net Link States (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum
10.10.10.1	1.1.1.1	833	0x80000001	0x9476
20.20.20.1	1.1.1.1	736	0x80000001	0x5d8b
30.30.30.1	1.1.1.1	690	0x80000001	0x26a0
40.40.40.1	2.2.2.2	637	0x80000001	0xf2a9
50.50.50.1	3.3.3.3	636	0x80000001	0x8de8
60.60.60.1	4.4.4.4	632	0x80000001	0x2828

Area-Local Opaque-LSA (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum	Opaque ID
1.0.0.1	1.1.1.1	734	0x80000003	0x2cf8	1
1.0.0.1	2.2.2.2	638	0x80000002	0x32eb	1
1.0.0.1	3.3.3.3	634	0x80000003	0x34e0	1
1.0.0.1	4.4.4.4	630	0x80000003	0x38d4	1
1.0.0.1	5.5.5.5	634	0x80000001	0x40c6	1
1.0.0.8	4.4.4.4	630	0x80000001	0x7b37	8
1.0.0.8	5.5.5.5	629	0x80000001	0x7b32	8
1.0.0.10	1.1.1.1	819	0x80000002	0xda05	10
1.0.0.10	2.2.2.2	818	0x80000002	0x8360	10
1.0.0.12	3.3.3.3	629	0x80000002	0xc924	12
1.0.0.12	5.5.5.5	629	0x80000002	0xab39	12
1.0.0.22	2.2.2.2	628	0x80000002	0xdd46	22
1.0.0.22	5.5.5.5	627	0x80000002	0xa175	22
1.0.0.30	1.1.1.1	693	0x80000002	0x7614	30
1.0.0.30	3.3.3.3	694	0x80000002	0x424d	30
1.0.0.32	1.1.1.1	648	0x80000002	0xc680	32
1.0.0.32	4.4.4.4	649	0x80000002	0xb597	32

PE2#show ip route summary

IP routing table name is Default-IP-Routing-Table(0)

IP routing table maximum-paths : 8
Total number of IPv4 routes : 14
Total number of IPv4 paths : 16

Pending routes (due to route max reached): 0

Route Source	Networks
kernel	1
connected	6
ospf	7
Total	14
FIB	14

ECMP statistics (active in ASIC):

Total number of IPv4 ECMP routes : 1
Total number of IPv4 ECMP paths : 3
Number of routes with 3 ECMP paths: 1

PE2#show ip interface brief

'*' - address is assigned by dhcp client

Interface	IP-Address	Admin-Status	Link-Status
xe0	*10.12.49.174	up	up
xe3	60.60.60.2	up	up
xe2	unassigned	up	up
xe2	50.50.50.2	up	up
xe4	unassigned	up	up
xe5	unassigned	up	up
xe6	unassigned	up	up
xe7	unassigned	up	up
xe1	40.40.40.2	up	up
xe9	unassigned	up	up
xe30	unassigned	up	up
xe31	unassigned	up	up
xe32	unassigned	up	up
xe33	unassigned	up	up
lo	127.0.0.1	up	up

PE2#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
1.1.1.1	xe1	Active	OPERATIONAL	30	00:10:40
2.2.2.2	xe1	Active	OPERATIONAL	30	00:10:58
3.3.3.3	xe2	Active	OPERATIONAL	30	00:10:58
4.4.4.4	xe3	Active	OPERATIONAL	30	00:10:59

PE2#show ip route

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP

O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,

ia - IS-IS inter area, E - EVPN,

v - vrf leaked

* - candidate default

IP Route Table for VRF "default"

Gateway of last resort is 10.12.49.1 to network 0.0.0.0

```

K*      0.0.0.0/0 [0/0] via 10.12.49.1, xe0
O       1.1.1.1/32 [110/3] via 60.60.60.1, xe3, 00:11:10
        [110/3] via 40.40.40.1, xe1
        [110/3] via 50.50.50.1, xe2
O       2.2.2.2/32 [110/2] via 40.40.40.1, xe1, 00:11:04
O       3.3.3.3/32 [110/2] via 50.50.50.1, xe2, 00:11:04
O       4.4.4.4/32 [110/2] via 60.60.60.1, xe3, 00:11:10
C       5.5.5.5/32 is directly connected, lo, 00:11:16
O       10.10.10.0/24 [110/2] via 40.40.40.1, xe1, 00:11:04
C       10.12.49.0/24 is directly connected, xe0, 16:28:18
O       20.20.20.0/24 [110/2] via 50.50.50.1, xe2, 00:11:04
O       30.30.30.0/24 [110/2] via 60.60.60.1, xe3, 00:11:10
C       40.40.40.0/24 is directly connected, xe1, 00:11:16
C       50.50.50.0/24 is directly connected, xe2, 00:11:16
C       60.60.60.0/24 is directly connected, xe3, 00:11:16
C       127.0.0.0/8 is directly connected, lo, 16:43:24

```

PE2#show ldp routes

Prefix Addr	Nexthop Addr	Intf	Owner
0.0.0.0/0	10.12.49.1	xe0	kernel
1.1.1.1/32	50.50.50.1	xe2	ospf
	40.40.40.1	xe1	ospf
	60.60.60.1	xe3	ospf
2.2.2.2/32	40.40.40.1	xe1	ospf
3.3.3.3/32	50.50.50.1	xe2	ospf
4.4.4.4/32	60.60.60.1	xe3	ospf
5.5.5.5/32	0.0.0.0	lo	connected
10.10.10.0/24	40.40.40.1	xe1	ospf
10.12.49.0/24	0.0.0.0	xe0	connected
20.20.20.0/24	50.50.50.1	xe2	ospf
30.30.30.0/24	60.60.60.1	xe3	ospf
40.40.40.0/24	0.0.0.0	xe1	connected
50.50.50.0/24	0.0.0.0	xe2	connected
60.60.60.0/24	0.0.0.0	xe3	connected

PE2#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	1.1.1.1/32	1	1	-	Yes	LSP_DEFAULT	25601
xe2	No	50.50.50.1					
			5	-	Yes	LSP_DEFAULT	25603
xe1	No	40.40.40.1					

```

xe3          No      60.60.60.1          9          -          Yes    LSP_DEFAULT 25600
L> 2.2.2.2/32          6          6          -          Yes    LSP_DEFAULT 3
xe1          No      40.40.40.1          2          -          Yes    LSP_DEFAULT 3
L> 3.3.3.3/32          2          2          -          Yes    LSP_DEFAULT 3
xe2          No      50.50.50.1          10         -          Yes    LSP_DEFAULT 3
L> 4.4.4.4/32          3          10         -          Yes    LSP_DEFAULT 3
xe3          No      60.60.60.1          6          -          Yes    LSP_DEFAULT 3
L> 10.10.10.0/24       7          6          -          Yes    LSP_DEFAULT 3
xe1          No      40.40.40.1          2          -          Yes    LSP_DEFAULT 3
L> 20.20.20.0/24       4          2          -          Yes    LSP_DEFAULT 3
xe2          No      50.50.50.1          10         -          Yes    LSP_DEFAULT 3
L> 30.30.30.0/24       5          10         -          Yes    LSP_DEFAULT 3
xe3          No      60.60.60.1

```

PE2#show mpls forwarding-table 5.5.5.5/32

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					

PE2#show mpls forwarding-table 1.1.1.1/32

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	1.1.1.1/32	1	1	-	Yes	LSP_DEFAULT	25601
xe2	No	50.50.50.1	5	-	Yes	LSP_DEFAULT	25603
xe1	No	40.40.40.1	9	-	Yes	LSP_DEFAULT	25600
xe3	No	60.60.60.1					

PE2#show ldp routes

Prefix	Addr	Nexthop	Addr	Intf	Owner
0.0.0.0/0		10.12.49.1		xe0	kernel
1.1.1.1/32		50.50.50.1		xe2	ospf
		40.40.40.1		xe1	ospf
		60.60.60.1		xe3	ospf
2.2.2.2/32		40.40.40.1		xe1	ospf
3.3.3.3/32		50.50.50.1		xe2	ospf
4.4.4.4/32		60.60.60.1		xe3	ospf
5.5.5.5/32		0.0.0.0		lo	connected
10.10.10.0/24		40.40.40.1		xe1	ospf
10.12.49.0/24		0.0.0.0		xe0	connected
20.20.20.0/24		50.50.50.1		xe2	ospf
30.30.30.0/24		60.60.60.1		xe3	ospf

```

40.40.40.0/24      0.0.0.0      xe1      connected
50.50.50.0/24      0.0.0.0      xe2      connected
60.60.60.0/24      0.0.0.0      xe3      connected

```

PE2#show ldp fec

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	NL>	2.2.2.2	25603	No	40.40.40.1
	NL>	3.3.3.3	25601	No	50.50.50.1
	NL>	4.4.4.4	25600	No	60.60.60.1
2.2.2.2/32	NL>	2.2.2.2	impl-null	No	40.40.40.1
3.3.3.3/32	NL>	3.3.3.3	impl-null	No	50.50.50.1
4.4.4.4/32	NL>	4.4.4.4	impl-null	No	60.60.60.1
5.5.5.5/32	E >	non-existent	none	No	connected
10.10.10.0/24	NL>	2.2.2.2	impl-null	No	40.40.40.1
10.12.49.0/24	NL	2.2.2.2	impl-null	No	connected
	NL	3.3.3.3	impl-null	No	connected
	NL	4.4.4.4	impl-null	No	connected
	E >	non-existent	none	No	connected
20.20.20.0/24	NL>	3.3.3.3	impl-null	No	50.50.50.1
30.30.30.0/24	NL>	4.4.4.4	impl-null	No	60.60.60.1
40.40.40.0/24	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
50.50.50.0/24	NL	3.3.3.3	impl-null	No	connected
	E >	non-existent	none	No	connected
60.60.60.0/24	NL	4.4.4.4	impl-null	No	connected
	E >	non-existent	none	No	connected

PE2#show ldp downstream

Session peer 1.1.1.1:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
-----	--------------	-------	-------	--------	------

Session peer 2.2.2.2:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
40.40.40.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.10.10.0/24	40.40.40.1	Established	impl-null	0	
2.2.2.2/32	40.40.40.1	Established	impl-null	0	
1.1.1.1/32	40.40.40.1	Established	25603	0	

Session peer 3.3.3.3:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
50.50.50.0/24	connected	Established	impl-null	0	
20.20.20.0/24	50.50.50.1	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
3.3.3.3/32	50.50.50.1	Established	impl-null	0	
1.1.1.1/32	50.50.50.1	Established	25601	0	

Session peer 4.4.4.4:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
60.60.60.0/24	connected	Established	impl-null	0	
30.30.30.0/24	60.60.60.1	Established	impl-null	0	

10.12.49.0/24	connected	Established	impl-null	0
4.4.4.4/32	60.60.60.1	Established	impl-null	0
1.1.1.1/32	60.60.60.1	Established	25600	0

PE2#show ldp lsp

DOWNSTREAM LSP :

FEC	Nexthop Addr	State	Label	Req.ID	Attr
1.1.1.1/32	40.40.40.1	Established	25603	0	
1.1.1.1/32	50.50.50.1	Established	25601	0	
1.1.1.1/32	60.60.60.1	Established	25600	0	
2.2.2.2/32	40.40.40.1	Established	impl-null	0	
3.3.3.3/32	50.50.50.1	Established	impl-null	0	
4.4.4.4/32	60.60.60.1	Established	impl-null	0	
5.5.5.5/32	connected	Established	none	0	None
10.10.10.0/24	40.40.40.1	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	none	0	None
20.20.20.0/24	50.50.50.1	Established	impl-null	0	
30.30.30.0/24	60.60.60.1	Established	impl-null	0	
40.40.40.0/24	connected	Established	impl-null	0	
40.40.40.0/24	connected	Established	none	0	None
50.50.50.0/24	connected	Established	impl-null	0	
50.50.50.0/24	connected	Established	none	0	None
60.60.60.0/24	connected	Established	impl-null	0	
60.60.60.0/24	connected	Established	none	0	None

UPSTREAM LSP :

FEC	State	Label	Req.ID	Attr
2.2.2.2/32	Established	25607	0	None
2.2.2.2/32	Established	25601	0	None
3.3.3.3/32	Established	25602	0	None
3.3.3.3/32	Established	25609	0	None
4.4.4.4/32	Established	25611	0	None
4.4.4.4/32	Established	25612	0	None
5.5.5.5/32	Established	impl-null	0	None
5.5.5.5/32	Established	impl-null	0	None
5.5.5.5/32	Established	impl-null	0	None
10.10.10.0/24	Established	25608	0	None
10.10.10.0/24	Established	25604	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	25605	0	None
20.20.20.0/24	Established	25610	0	None
30.30.30.0/24	Established	25613	0	None
30.30.30.0/24	Established	25614	0	None
40.40.40.0/24	Established	impl-null	0	None
40.40.40.0/24	Established	impl-null	0	None

40.40.40.0/24	Established	impl-null	0	None
50.50.50.0/24	Established	impl-null	0	None
50.50.50.0/24	Established	impl-null	0	None
50.50.50.0/24	Established	impl-null	0	None
60.60.60.0/24	Established	impl-null	0	None
60.60.60.0/24	Established	impl-null	0	None
60.60.60.0/24	Established	impl-null	0	None
60.60.60.0/24	Established	impl-null	0	None
60.60.60.0/24	Established	impl-null	0	None

PE2#show ldp fec prefix 1.1.1.1/32

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	NL>	2.2.2.2	25603	No	40.40.40.1
	NL>	3.3.3.3	25601	No	50.50.50.1
	NL>	4.4.4.4	25600	No	60.60.60.1

PE2#show router-id

Name: management

Router ID is not set

Name: default

Router ID: 10.12.49.174 (automatic)

PE2#show mpls ftn-table

Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: LDP, Stale: NO, out intf: xe2, out label: 25601

Nexthop addr: 50.50.50.1 cross connect ix: 2, op code: Push

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 5

Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe1, out label: 25603

Nexthop addr: 40.40.40.1 cross connect ix: 2, op code: Push

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 9

Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present

Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe3, out label: 25600

Nexthop addr: 60.60.60.1 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 2.2.2.2/32, id: 6, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 40.40.40.1 cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 50.50.50.1 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 10
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe3, out label: 3
Nexthop addr: 60.60.60.1 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.10.10.0/24, id: 7, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 40.40.40.1 cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 20.20.20.0/24, id: 4, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 50.50.50.1 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 30.30.30.0/24, id: 5, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 10

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe3, out label: 3

Nexthop addr: 60.60.60.1 cross connect ix: 1, op code: Push

PE2#show mpls ftn-table 1.1.1.1/32

Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: LDP, Stale: NO, out intf: xe2, out label: 25601

Nexthop addr: 50.50.50.1 cross connect ix: 2, op code: Push

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 5

Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe1, out label: 25603

Nexthop addr: 40.40.40.1 cross connect ix: 2, op code: Push

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 9

Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present

Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe3, out label: 25600

Nexthop addr: 60.60.60.1 cross connect ix: 2, op code: Push

PE2#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup

K - CLI ILM, T - MPLS-TP, s - Stitched ILM

S - SNMP, L - LDP, R - RSVP, C - CRLDP

B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT

O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI

P - SR Policy, U - unknown

Code Type	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF	Nexthop	pri	LSP-
L>	3.3.3.3/32	10	25609	3	N/A	xe2	50.50.50.1	Yes	LSP_DEFAULT
L>	20.20.20.0/24	6	25605	3	N/A	xe2	50.50.50.1	Yes	LSP_DEFAULT
L>	3.3.3.3/32	3	25602	3	N/A	xe2	50.50.50.1	Yes	LSP_DEFAULT
L>	2.2.2.2/32	2	25601	3	N/A	xe1	40.40.40.1	Yes	LSP_DEFAULT
L>	10.10.10.0/24	5	25604	3	N/A	xe1	40.40.40.1	Yes	LSP_DEFAULT
L>	2.2.2.2/32	8	25607	3	N/A	xe1	40.40.40.1	Yes	LSP_DEFAULT
L>	10.10.10.0/24	9	25608	3	N/A	xe1	40.40.40.1	Yes	LSP_DEFAULT
L>	4.4.4.4/32	12	25611	3	N/A	xe3	60.60.60.1	Yes	LSP_DEFAULT
L>	20.20.20.0/24	11	25610	3	N/A	xe2	50.50.50.1	Yes	LSP_DEFAULT
L>	30.30.30.0/24	14	25613	3	N/A	xe3	60.60.60.1	Yes	LSP_DEFAULT
L>	4.4.4.4/32	13	25612	3	N/A	xe3	60.60.60.1	Yes	LSP_DEFAULT
L>	30.30.30.0/24	15	25614	3	N/A	xe3	60.60.60.1	Yes	LSP_DEFAULT

RTR1 - FRR Configuration

Now that NSM, OSPF and LDP are all configured, FRR for IGP and LDP can be enabled using below configurations.

#configure terminal	Enter configuration mode.
(config)#router ospf 1	Configure the routing process and specify the Process ID <ul style="list-style-type: none"> The Process ID should be a unique positive integer identifying the routing process.
(config-router)#fast-reroute keep-all-paths	Configure OSPF LFA-FRR to calculate the available backup path
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#fast-reroute	Configure LDP LFA-FRR to calculate the available backup path
(config-router)#exit	Exit router mode.
(config)#commit	Commit all the configurations

Validation

```
PE1#show ip route fast-reroute
```

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP

O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area ,p - stale info, E - EVPN

* - candidate default

IP Route Table for VRF "default"

```
O      2.2.2.2/32 [110/11] via 10.10.10.2, xe2, 00:38:00
          [FRR-NH] via 20.20.20.2, xe12
```

```
O      3.3.3.3/32 [110/13] via 10.10.10.2, xe2, 00:34:47
          [FRR-NH] via 20.20.20.2, xe12
```

```
O      4.4.4.4/32 [110/13] via 10.10.10.2, xe2, 00:34:47
          [FRR-NH] via 20.20.20.2, xe12
```

```
O      5.5.5.5/32 [110/12] via 10.10.10.2, xe2, 00:34:49
          [FRR-NH] via 20.20.20.2, xe12
```

```
O      40.40.40.0/24 [110/11] via 10.10.10.2, xe2, 00:34:49
          [FRR-NH] via 20.20.20.2, xe12
```

```
O      50.50.50.0/24 [110/12] via 10.10.10.2, xe2, 00:34:47
          [FRR-NH] via 20.20.20.2, xe12
```

```
O      60.60.60.0/24 [110/12] via 10.10.10.2, xe2, 00:34:47
      [FRR-NH] via 20.20.20.2, xe12
```

```
PE1#show ip ospf route fast-reroute
```

```
OSPF process 1:
```

```
Codes: C - connected, D - Discard, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      OSPF LFA attributes:
      P - Primary, SP - Secondary-Path, LP - Link Protecting,
      NP - Node Protecting, BID - Broadcast Link Protecting
      DP - Downstream Protecting
```

```
O  2.2.2.2/32 [11] via 10.10.10.2, xe2, Area 0.0.0.0
      Backup path:
      via 20.20.20.2, xe12, Area 0.0.0.0
      Attributes: Metric: [18] ,SP ,BID ,DP
O  3.3.3.3/32 [13] via 10.10.10.2, xe2, Area 0.0.0.0
      Backup path:
      via 20.20.20.2, xe12, Area 0.0.0.0
      Attributes: Metric: [16] ,SP ,NP ,BID ,DP
O  4.4.4.4/32 [13] via 10.10.10.2, xe2, Area 0.0.0.0
      Backup path:
      via 20.20.20.2, xe12, Area 0.0.0.0
      Attributes: Metric: [18] ,SP ,NP ,BID ,DP
O  5.5.5.5/32 [12] via 10.10.10.2, xe2, Area 0.0.0.0
      Backup path:
      via 20.20.20.2, xe12, Area 0.0.0.0
      Attributes: Metric: [17] ,SP ,NP ,BID ,DP
O  20.20.20.0/24 [13] via 10.10.10.2, xe2, Area 0.0.0.0
      Backup path:
      via 20.20.20.2, xe12, Area 0.0.0.0
      Attributes: Metric: [16] ,SP ,NP ,BID ,DP
O  30.30.30.0/24 [13] via 10.10.10.2, xe2, Area 0.0.0.0
      Backup path:
      via 20.20.20.2, xe12, Area 0.0.0.0
      Attributes: Metric: [18] ,SP ,NP ,BID ,DP
O  40.40.40.0/24 [11] via 10.10.10.2, xe2, Area 0.0.0.0
      Backup path:
      via 20.20.20.2, xe12, Area 0.0.0.0
      Attributes: Metric: [17] ,SP ,NP ,BID ,DP
O  50.50.50.0/24 [12] via 10.10.10.2, xe2, Area 0.0.0.0
      Backup path:
      via 20.20.20.2, xe12, Area 0.0.0.0
      Attributes: Metric: [16] ,SP ,NP ,BID ,DP
O  60.60.60.0/24 [12] via 10.10.10.2, xe2, Area 0.0.0.0
      Backup path:
      via 20.20.20.2, xe12, Area 0.0.0.0
```

Attributes: Metric: [17] ,SP ,NP ,BID ,DP

PE1#show ldp routes

Prefix Addr	Nexthop Addr	Intf	Backup Addr	Backup Intf	Owner
0.0.0.0/0	10.12.49.1	xe0	-	-	kernel
1.1.1.1/32	0.0.0.0	lo	-	-	connected
2.2.2.2/32	10.10.10.2	xe2	20.20.20.2	xe12	ospf
3.3.3.3/32	10.10.10.2	xe2	20.20.20.2	xe12	ospf
4.4.4.4/32	10.10.10.2	xe2	20.20.20.2	xe12	ospf
5.5.5.5/32	10.10.10.2	xe2	20.20.20.2	xe12	ospf
10.10.10.0/24	0.0.0.0	xe2	-	-	connected
10.12.49.0/24	0.0.0.0	xe0	-	-	connected
20.20.20.0/24	0.0.0.0	xe12	-	-	connected
30.30.30.0/24	0.0.0.0	xe13	-	-	connected
40.40.40.0/24	10.10.10.2	xe2	20.20.20.2	xe12	ospf
50.50.50.0/24	10.10.10.2	xe2	20.20.20.2	xe12	ospf
60.60.60.0/24	10.10.10.2	xe2	20.20.20.2	xe12	ospf

PE1#show ldp fec

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 P - Primary route, B - LFA Backup route,
 R - Remote LFA Backup route,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	E >	non-existent	none	No	connected
2.2.2.2/32	NL	4.4.4.4	25608	No	no nexthop
	NLB>	3.3.3.3	25607	No	20.20.20.2
	NLP>	2.2.2.2	impl-null	No	10.10.10.2
3.3.3.3/32	NL	4.4.4.4	25609	No	no nexthop
	NLP>	2.2.2.2	25601	No	10.10.10.2
	NLB>	3.3.3.3	impl-null	No	20.20.20.2
4.4.4.4/32	NLB>	3.3.3.3	25608	No	20.20.20.2
	NLP>	2.2.2.2	25602	No	10.10.10.2
	NL	4.4.4.4	impl-null	No	no nexthop
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NLP>	2.2.2.2	25600	No	10.10.10.2
	NLB>	3.3.3.3	25600	No	20.20.20.2
10.10.10.0/24	NL	4.4.4.4	25611	No	connected
	NL	3.3.3.3	25610	No	connected
	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
10.12.49.0/24	NL	4.4.4.4	impl-null	No	connected
	NL	3.3.3.3	impl-null	No	connected
	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
20.20.20.0/24	NL	4.4.4.4	25612	No	connected
	NL	2.2.2.2	25610	No	connected
	NL	3.3.3.3	impl-null	No	connected
	E >	non-existent	none	No	connected

30.30.30.0/24	NL	3.3.3.3	25611	No	connected
	NL	2.2.2.2	25611	No	connected
	NL	4.4.4.4	impl-null	No	connected
	E >	non-existent	none	No	connected
40.40.40.0/24	NL	4.4.4.4	25613	No	no nexthop
	NLB>	3.3.3.3	25612	No	20.20.20.2
	NLP>	2.2.2.2	impl-null	No	10.10.10.2
50.50.50.0/24	NL	4.4.4.4	25614	No	no nexthop
	NLP>	2.2.2.2	25612	No	10.10.10.2
	NLB>	3.3.3.3	impl-null	No	20.20.20.2
60.60.60.0/24	NLP>	2.2.2.2	25609	No	10.10.10.2
	NLB>	3.3.3.3	25609	No	20.20.20.2
	NL	4.4.4.4	impl-null	No	no nexthop

PE1#show ldp downstream

Codes: P - Primary route, B - Backup route

Session peer 5.5.5.5:

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
----------	--------------	-------	-------	--------	------

Codes: P - Primary route, B - Backup route

Session peer 2.2.2.2:

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
----------	--------------	-------	-------	--------	------

50.50.50.0/24	10.10.10.2	Established	25612	0	
P					
30.30.30.0/24	connected	Established	25611	0	
20.20.20.0/24	connected	Established	25610	0	
4.4.4.4/32	10.10.10.2	Established	25602	0	
P					
3.3.3.3/32	10.10.10.2	Established	25601	0	
P					
60.60.60.0/24	10.10.10.2	Established	25609	0	
P					
5.5.5.5/32	10.10.10.2	Established	25600	0	
P					
40.40.40.0/24	10.10.10.2	Established	impl-null	0	
P					
10.12.49.0/24	connected	Established	impl-null	0	
10.10.10.0/24	connected	Established	impl-null	0	
2.2.2.2/32	10.10.10.2	Established	impl-null	0	
P					

Codes: P - Primary route, B - Backup route

Session peer 3.3.3.3:

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
----------	--------------	-------	-------	--------	------

40.40.40.0/24	connected	Established	25612	0	
40.40.40.0/24	20.20.20.2	Established	25612	0	
B					
30.30.30.0/24	connected	Established	25611	0	
10.10.10.0/24	connected	Established	25610	0	
4.4.4.4/32	connected	Established	25608	0	
4.4.4.4/32	20.20.20.2	Established	25608	0	
B					
2.2.2.2/32	connected	Established	25607	0	

2.2.2.2/32	20.20.20.2	Established	25607	0	
B					
60.60.60.0/24	connected	Established	25609	0	
60.60.60.0/24	20.20.20.2	Established	25609	0	
B					
5.5.5.5/32	connected	Established	25600	0	
5.5.5.5/32	20.20.20.2	Established	25600	0	
B					
50.50.50.0/24	connected	Established	impl-null	0	
50.50.50.0/24	20.20.20.2	Established	impl-null	0	
B					
20.20.20.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
3.3.3.3/32	connected	Established	impl-null	0	
3.3.3.3/32	20.20.20.2	Established	impl-null	0	

B

Codes: P - Primary route, B - Backup route

Session peer 4.4.4.4:

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
50.50.50.0/24	connected	Established	25614	0	
40.40.40.0/24	connected	Established	25613	0	
20.20.20.0/24	connected	Established	25612	0	
10.10.10.0/24	connected	Established	25611	0	
5.5.5.5/32	connected	Established	25610	0	
3.3.3.3/32	connected	Established	25609	0	
2.2.2.2/32	connected	Established	25608	0	
60.60.60.0/24	connected	Established	impl-null	0	
30.30.30.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
4.4.4.4/32	connected	Established	impl-null	0	

PE1#show ldp lsp

DOWNSTREAM LSP :

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
1.1.1.1/32	connected	Established	none	0	None
2.2.2.2/32	connected	Established	25608	0	
2.2.2.2/32	connected	Established	25607	0	
2.2.2.2/32	20.20.20.2	Established	25607	0	
B					
2.2.2.2/32	10.10.10.2	Established	impl-null	0	
P					
3.3.3.3/32	connected	Established	25609	0	
3.3.3.3/32	10.10.10.2	Established	25601	0	
P					
3.3.3.3/32	connected	Established	impl-null	0	
3.3.3.3/32	20.20.20.2	Established	impl-null	0	
B					
4.4.4.4/32	connected	Established	25608	0	
4.4.4.4/32	20.20.20.2	Established	25608	0	
B					

P	4.4.4.4/32	10.10.10.2	Established	25602	0	
	4.4.4.4/32	connected	Established	impl-null	0	
	5.5.5.5/32	connected	Established	25610	0	
P	5.5.5.5/32	10.10.10.2	Established	25600	0	
	5.5.5.5/32	connected	Established	25600	0	
B	5.5.5.5/32	20.20.20.2	Established	25600	0	
	10.10.10.0/24	connected	Established	25611	0	
	10.10.10.0/24	connected	Established	25610	0	
	10.10.10.0/24	connected	Established	impl-null	0	
	10.10.10.0/24	connected	Established	none	0	None
	10.12.49.0/24	connected	Established	impl-null	0	
	10.12.49.0/24	connected	Established	impl-null	0	
	10.12.49.0/24	connected	Established	impl-null	0	
	10.12.49.0/24	connected	Established	none	0	None
	20.20.20.0/24	connected	Established	25612	0	
	20.20.20.0/24	connected	Established	25610	0	
	20.20.20.0/24	connected	Established	impl-null	0	
	20.20.20.0/24	connected	Established	none	0	None
	30.30.30.0/24	connected	Established	25611	0	
	30.30.30.0/24	connected	Established	25611	0	
	30.30.30.0/24	connected	Established	impl-null	0	
	30.30.30.0/24	connected	Established	none	0	None
	40.40.40.0/24	connected	Established	25613	0	
	40.40.40.0/24	connected	Established	25612	0	
B	40.40.40.0/24	20.20.20.2	Established	25612	0	
P	40.40.40.0/24	10.10.10.2	Established	impl-null	0	
	50.50.50.0/24	connected	Established	25614	0	
P	50.50.50.0/24	10.10.10.2	Established	25612	0	
	50.50.50.0/24	connected	Established	impl-null	0	
B	50.50.50.0/24	20.20.20.2	Established	impl-null	0	
P	60.60.60.0/24	10.10.10.2	Established	25609	0	
	60.60.60.0/24	connected	Established	25609	0	
B	60.60.60.0/24	20.20.20.2	Established	25609	0	
	60.60.60.0/24	connected	Established	impl-null	0	
UPSTREAM LSP :						
	FEC	State	Label	Req.ID	Attr	
	1.1.1.1/32	Established	impl-null	0	None	
	1.1.1.1/32	Established	impl-null	0	None	
	1.1.1.1/32	Established	impl-null	0	None	
	2.2.2.2/32	Established	25608	0	None	
	2.2.2.2/32	Established	25602	0	None	
	2.2.2.2/32	Established	25608	0	None	

3.3.3.3/32	Established	25614	0	None
3.3.3.3/32	Established	25609	0	None
3.3.3.3/32	Established	25609	0	None
4.4.4.4/32	Established	25615	0	None
4.4.4.4/32	Established	25605	0	None
4.4.4.4/32	Established	25615	0	None
4.4.4.4/32	Established	25605	0	None
5.5.5.5/32	Established	25606	0	None
5.5.5.5/32	Established	25613	0	None
5.5.5.5/32	Established	25613	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
40.40.40.0/24	Established	25610	0	None
40.40.40.0/24	Established	25603	0	None
40.40.40.0/24	Established	25610	0	None
50.50.50.0/24	Established	25616	0	None
50.50.50.0/24	Established	25611	0	None
50.50.50.0/24	Established	25611	0	None
60.60.60.0/24	Established	25607	0	None
60.60.60.0/24	Established	25612	0	None
60.60.60.0/24	Established	25612	0	None
60.60.60.0/24	Established	25607	0	None

```
PE1#show ldp fec prefix 5.5.5.5/32
```

```
LSR codes      : E/N - LSR is egress/non-egress for this FEC,
                L - LSR received a label for this FEC,
                P - Primary route, B - LFA Backup route,
                R - Remote LFA Backup route,
                > - LSR will use this route for the FEC
```

FEC	Code	Session	Out Label	ELC	Nexthop Addr
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NLP>	2.2.2.2	25600	No	10.10.10.2
	NLB>	3.3.3.3	25600	No	20.20.20.2

```
PE1#show mpls forwarding-table
```

```
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
```


Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	1	-	Yes	LSP_DEFAULT	3
xe2	No	10.10.10.2					
			2	-	No	LSP_DEFAULT	25607
xe12	No	20.20.20.2					
L>	3.3.3.3/32	3	9	-	Yes	LSP_DEFAULT	25601
xe2	No	10.10.10.2					
			3	-	No	LSP_DEFAULT	3
xe12	No	20.20.20.2					
L>	4.4.4.4/32	5	10	-	Yes	LSP_DEFAULT	25602
xe2	No	10.10.10.2					
			4	-	No	LSP_DEFAULT	25608
xe12	No	20.20.20.2					
L>	5.5.5.5/32	7	7	-	Yes	LSP_DEFAULT	25600
xe2	No	10.10.10.2					
			5	-	No	LSP_DEFAULT	25600
xe12	No	20.20.20.2					
L>	40.40.40.0/24	2	1	-	Yes	LSP_DEFAULT	3
xe2	No	10.10.10.2					
			6	-	No	LSP_DEFAULT	25612
xe12	No	20.20.20.2					
L>	50.50.50.0/24	4	11	-	Yes	LSP_DEFAULT	25612
xe2	No	10.10.10.2					
			3	-	No	LSP_DEFAULT	3
xe12	No	20.20.20.2					
L>	60.60.60.0/24	6	8	-	Yes	LSP_DEFAULT	25609
xe2	No	10.10.10.2					
			12	-	No	LSP_DEFAULT	25609
xe12	No	20.20.20.2					

PE1#show mpls forwarding-table 5.5.5.5/32

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	5.5.5.5/32	7	7	-	Yes	LSP_DEFAULT	25600
xe2	No	10.10.10.2					
			5	-	No	LSP_DEFAULT	25600
xe12	No	20.20.20.2					

PE1#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
 Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
 Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
 Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3
 Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 2
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xe12, out label: 25607
Nexthop addr: 20.20.20.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 9
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe2, out label: 25601
Nexthop addr: 10.10.10.2 cross connect ix: 5, op code: Push

Backup Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 3
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe12, out label: 3
Nexthop addr: 20.20.20.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 10
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 10, owner: LDP, Stale: NO, out intf: xe2, out label: 25602
Nexthop addr: 10.10.10.2 cross connect ix: 6, op code: Push

Backup Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe12, out label: 25608
Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:391, pkts:5, TX bytes:411, Pushed pkts:5
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25600
Nexthop addr: 10.10.10.2 cross connect ix: 2, op code: Push

Backup Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe12, out label: 25600

Nexthop addr: 20.20.20.2 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 6

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe12, out label: 25612

Nexthop addr: 20.20.20.2 cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 50.50.50.0/24, id: 4, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 11

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe2, out label: 25612

Nexthop addr: 10.10.10.2 cross connect ix: 7, op code: Push

Backup Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe12, out label: 3

Nexthop addr: 20.20.20.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 60.60.60.0/24, id: 6, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe2, out label: 25609

Nexthop addr: 10.10.10.2 cross connect ix: 8, op code: Push

Backup Cross connect ix: 13, in intf: - in label: 0 out-segment ix: 12

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe12, out label: 25609

Nexthop addr: 20.20.20.2 cross connect ix: 13, op code: Push

```
PE1#show mpls ftn-table 5.5.5.5/32
```

```
Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
```

```
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
```

```
Matched bytes:391, pkts:5, TX bytes:411, Pushed pkts:5
```

```
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
```

```
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25600
```

```
Nexthop addr: 10.10.10.2 cross connect ix: 2, op code: Push
```

```
Backup Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 5
```

```
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe12, out label: 25600
```

```
Nexthop addr: 20.20.20.2 cross connect ix: 7, op code: Push
```

```
PE1#show mpls ilm-table
```

```
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
```

```
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
```

```
S - SNMP, L - LDP, R - RSVP, C - CRLDP
```

```
B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
```

```
O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
```

```
P - SR Policy, U - unknown
```

Code Nexthop Type	FEC/VRF/L2CKT	ILM-ID pri	In-Label LSP-	Out-Label	In-Intf	Out-Intf/VRF
L> 2.2.2.2/32 10.10.10.2 DEFAULT	9 Yes		25608 LSP_	3	N/A	xe2
20.20.20.2 DEFAULT	No		25608 LSP_	25607	N/A	xe12
L> 4.4.4.4/32 10.10.10.2 DEFAULT	6 Yes		25605 LSP_	25602	N/A	xe2
L> 2.2.2.2/32 10.10.10.2 DEFAULT	3 Yes		25602 LSP_	3	N/A	xe2
L> 40.40.40.0/24 10.10.10.2 DEFAULT	4 Yes		25603 LSP_	3	N/A	xe2
L> 5.5.5.5/32 10.10.10.2 DEFAULT	7 Yes		25606 LSP_	25600	N/A	xe2
L> 60.60.60.0/24 10.10.10.2 DEFAULT	8 Yes		25607 LSP_	25609	N/A	xe2
L> 60.60.60.0/24 10.10.10.2	13 Yes		25612 LSP_	25609	N/A	xe2

DEFAULT						
20.20.20.2	No	LSP_	25612	25609	N/A	xe12
DEFAULT						
L> 40.40.40.0/24	11		25610	3	N/A	xe2
10.10.10.2	Yes	LSP_				
DEFAULT						
20.20.20.2	No	LSP_	25610	25612	N/A	xe12
DEFAULT						
L> 3.3.3.3/32	10		25609	25601	N/A	xe2
10.10.10.2	Yes	LSP_				
DEFAULT						
20.20.20.2	No	LSP_	25609	3	N/A	xe12
DEFAULT						
L> 50.50.50.0/24	12		25611	25612	N/A	xe2
10.10.10.2	Yes	LSP_				
DEFAULT						
20.20.20.2	No	LSP_	25611	3	N/A	xe12
DEFAULT						
L> 3.3.3.3/32	15		25614	25601	N/A	xe2
10.10.10.2	Yes	LSP_				
DEFAULT						
L> 5.5.5.5/32	14		25613	25600	N/A	xe2
10.10.10.2	Yes	LSP_				
DEFAULT						
20.20.20.2	No	LSP_	25613	25600	N/A	xe12
DEFAULT						
L> 4.4.4.4/32	16		25615	25602	N/A	xe2
10.10.10.2	Yes	LSP_				
DEFAULT						
20.20.20.2	No	LSP_	25615	25608	N/A	xe12
DEFAULT						
L> 50.50.50.0/24	17		25616	25612	N/A	xe2
10.10.10.2	Yes	LSP_				
DEFAULT						

PE1#show ip ospf neighbor

Total number of full neighbors: 3						
OSPF process 1 VRF(default):						
Neighbor ID	Pri	State	Dead Time	Address	Interface	
Instance ID						
2.2.2.2	1	Full/Backup	00:00:31	10.10.10.2	xe2	0
3.3.3.3	1	Full/Backup	00:00:29	20.20.20.2	xe12	0
4.4.4.4	1	Full/Backup	00:00:39	30.30.30.2	xe13	0

PE1#show ip ospf interface brief							
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
lo	1	0.0.0.0	1	1	Loopback	0	Up

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
xe2	1	0.0.0.0	4	10	DR	1	Up

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
xe12	1	0.0.0.0	14	15	DR	1	Up

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
xe13	1	0.0.0.0	15	20	DR	1	Up

```
PE1#show ip ospf database
```

```
OSPF Router with ID (1.1.1.1) (Process ID 1 VRF default)
```

```
Router Link States (Area 0.0.0.0)
```

Link ID	ADV Router	Age	Seq#	CkSum	Link count
1.1.1.1	1.1.1.1	473	0x8000000f	0x5af3	4
2.2.2.2	2.2.2.2	504	0x80000009	0x5f60	3
3.3.3.3	3.3.3.3	430	0x80000009	0x62d8	3
4.4.4.4	4.4.4.4	425	0x80000009	0x6551	3
5.5.5.5	5.5.5.5	505	0x80000005	0xd45c	4

```
Net Link States (Area 0.0.0.0)
```

Link ID	ADV Router	Age	Seq#	CkSum
10.10.10.1	1.1.1.1	913	0x80000002	0x9277
20.20.20.1	1.1.1.1	1133	0x80000002	0x5b8c
30.30.30.1	1.1.1.1	1053	0x80000002	0x24a1
40.40.40.1	2.2.2.2	2263	0x80000001	0xf2a9
50.50.50.1	3.3.3.3	600	0x80000002	0x8be9
60.60.60.1	4.4.4.4	595	0x80000002	0x2629

```
Area-Local Opaque-LSA (Area 0.0.0.0)
```

Link ID	ADV Router	Age	Seq#	CkSum	Opaque ID
1.0.0.1	1.1.1.1	553	0x80000004	0x2af9	1
1.0.0.1	2.2.2.2	454	0x80000003	0x30ec	1
1.0.0.1	3.3.3.3	460	0x80000004	0x32e1	1
1.0.0.1	4.4.4.4	465	0x80000004	0x36d5	1
1.0.0.1	5.5.5.5	985	0x80000002	0x3ec7	1
1.0.0.8	4.4.4.4	705	0x80000002	0x7938	8
1.0.0.8	5.5.5.5	2257	0x80000001	0x7b32	8
1.0.0.10	1.1.1.1	693	0x80000003	0xd806	10
1.0.0.10	2.2.2.2	694	0x80000003	0x8161	10
1.0.0.12	3.3.3.3	470	0x80000003	0xc725	12
1.0.0.12	5.5.5.5	505	0x80000003	0xa93a	12
1.0.0.22	2.2.2.2	424	0x80000003	0xdb47	22
1.0.0.22	5.5.5.5	445	0x80000003	0x9f76	22
1.0.0.30	1.1.1.1	563	0x80000003	0x7415	30

```
1.0.0.30      3.3.3.3      570      0x80000003 0x404e 30
1.0.0.32      1.1.1.1      473      0x80000003 0xc481 32
1.0.0.32      4.4.4.4      525      0x80000003 0xb398 32
```

PE1#

PE1#show ip route summary

IP routing table name is Default-IP-Routing-Table(0)

```
IP routing table maximum-paths   : 8
Total number of IPv4 routes      : 14
Total number of IPv4 paths       : 14
Pending routes (due to route max reached): 0
Route Source    Networks
kernel          1
connected       6
ospf            7
Total           14
FIB             14
```

ECMP statistics (active in ASIC):

```
Total number of IPv4 ECMP routes : 0
Total number of IPv4 ECMP paths  : 0
```

LFA Non ECMP statistics

Total number of Routes : 7
Total number of Primary Paths : 7
Total number of Backup Paths : 7

PE1#

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
5.5.5.5	xe12	Passive	OPERATIONAL	30	00:38:05
2.2.2.2	xe2	Passive	OPERATIONAL	30	00:41:33
3.3.3.3	xe12	Passive	OPERATIONAL	30	00:39:27
4.4.4.4	xe13	Passive	OPERATIONAL	30	00:38:42

PE1#

PE1#show ip route

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
ia - IS-IS inter area, E - EVPN,
v - vrf leaked
* - candidate default

IP Route Table for VRF "default"

Gateway of last resort is 10.12.49.1 to network 0.0.0.0

```

K*      0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C      1.1.1.1/32 is directly connected, lo, 00:47:32
O      2.2.2.2/32 [110/11] via 10.10.10.2, xe2, 00:41:44
O      3.3.3.3/32 [110/13] via 10.10.10.2, xe2, 00:38:31
O      4.4.4.4/32 [110/13] via 10.10.10.2, xe2, 00:38:31
O      5.5.5.5/32 [110/12] via 10.10.10.2, xe2, 00:38:33
C      10.10.10.0/24 is directly connected, xe2, 00:45:41
C      10.12.49.0/24 is directly connected, xe0, 16:57:41
C      20.20.20.0/24 is directly connected, xe12, 00:45:41
C      30.30.30.0/24 is directly connected, xe13, 00:45:41
O      40.40.40.0/24 [110/11] via 10.10.10.2, xe2, 00:38:33
O      50.50.50.0/24 [110/12] via 10.10.10.2, xe2, 00:38:31
O      60.60.60.0/24 [110/12] via 10.10.10.2, xe2, 00:38:31
C      127.0.0.0/8 is directly connected, lo, 17:11:17

```

To prohibit an interface from being used as a repair path, disable fast reroute calculation on the interface:

#configure terminal	Enter configuration mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip ospf fast-reroute per-prefix candidate disable	Disable fast reroute calculation on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit all the configurations

Verify that the xe2 interface is not used for backup path calculation.

```

PE1#show ip route fast-reroute
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area ,p -
stale info, E - EVPN
       * - candidate default

```

```

IP Route Table for VRF "default"
O      2.2.2.2/32 [110/11] via 10.10.10.2, xe1, 00:47:05
       [FRR-NH] via 30.30.30.2, xe3

O      3.3.3.3/32 [110/13] via 10.10.10.2, xe1, 00:43:52
       [FRR-NH] via 30.30.30.2, xe3

O      4.4.4.4/32 [110/13] via 10.10.10.2, xe1, 00:43:52
       [FRR-NH] via 30.30.30.2, xe3

O      5.5.5.5/32 [110/12] via 10.10.10.2, xe1, 00:43:54
       [FRR-NH] via 30.30.30.2, xe3

```



```
O      40.40.40.0/24 [110/11] via 10.10.10.2, xe1, 00:43:54
      [FRR-NH] via 30.30.30.2, xe3

O      50.50.50.0/24 [110/12] via 10.10.10.2, xe1, 00:43:52
      [FRR-NH] via 30.30.30.2, xe3

O      60.60.60.0/24 [110/12] via 10.10.10.2, xe1, 00:43:52
      [FRR-NH] via 30.30.30.2, xe3
```

```
PE1#show ip ospf route fast-reroute
```

```
OSPF process 1:
```

```
Codes: C - connected, D - Discard, O - OSPF, IA - OSPF inter area
```

```
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
```

```
      E1 - OSPF external type 1, E2 - OSPF external type 2
```

```
OSPF LFA attributes:
```

```
      P - Primary, SP - Secondary-Path, LP - Link Protecting,
```

```
      NP - Node Protecting, BID - Broadcast Link Protecting
```

```
      DP - Downstream Protecting
```

```
O  2.2.2.2/32 [11] via 10.10.10.2, xe1, Area 0.0.0.0
      Backup path:
      via 30.30.30.2, xe3, Area 0.0.0.0
      Attributes: Metric: [23] ,SP ,BID ,DP

O  3.3.3.3/32 [13] via 10.10.10.2, xe1, Area 0.0.0.0
      Backup path:
      via 30.30.30.2, xe3, Area 0.0.0.0
      Attributes: Metric: [23] ,SP ,NP ,BID ,DP

O  4.4.4.4/32 [13] via 10.10.10.2, xe1, Area 0.0.0.0
      Backup path:
      via 30.30.30.2, xe3, Area 0.0.0.0
      Attributes: Metric: [21] ,SP ,NP ,BID ,DP

O  5.5.5.5/32 [12] via 10.10.10.2, xe1, Area 0.0.0.0
      Backup path:
      via 30.30.30.2, xe3, Area 0.0.0.0
      Attributes: Metric: [22] ,SP ,NP ,BID ,DP

O  20.20.20.0/24 [13] via 10.10.10.2, xe1, Area 0.0.0.0
      Backup path:
      via 30.30.30.2, xe3, Area 0.0.0.0
      Attributes: Metric: [23] ,SP ,NP ,BID ,DP

O  30.30.30.0/24 [13] via 10.10.10.2, xe1, Area 0.0.0.0
      Backup path:
      via 30.30.30.2, xe3, Area 0.0.0.0
      Attributes: Metric: [21] ,SP ,NP ,BID ,DP

O  40.40.40.0/24 [11] via 10.10.10.2, xe1, Area 0.0.0.0
      Backup path:
      via 30.30.30.2, xe3, Area 0.0.0.0
      Attributes: Metric: [22] ,SP ,NP ,BID ,DP

O  50.50.50.0/24 [12] via 10.10.10.2, xe1, Area 0.0.0.0
      Backup path:
```

```

        via 30.30.30.2, xe3, Area 0.0.0.0
        Attributes: Metric: [22] ,SP ,NP ,BID ,DP
O 60.60.60.0/24 [12] via 10.10.10.2, xe1, Area 0.0.0.0
    Backup path:
        via 30.30.30.2, xe3, Area 0.0.0.0
        Attributes: Metric: [21] ,SP ,NP ,BID ,DP

```

PE1#show ldp routes

Prefix Addr	Nexthop Addr	Intf	Backup Addr	Backup Intf	Owner
0.0.0.0/0	10.12.49.1	xe0	-	-	kernel
1.1.1.1/32	0.0.0.0	lo	-	-	connected
2.2.2.2/32	10.10.10.2	xe1	30.30.30.2	xe3	ospf
3.3.3.3/32	10.10.10.2	xe1	30.30.30.2	xe3	ospf
4.4.4.4/32	10.10.10.2	xe1	30.30.30.2	xe3	ospf
5.5.5.5/32	10.10.10.2	xe1	30.30.30.2	xe3	ospf
10.10.10.0/24	0.0.0.0	xe1	-	-	connected
10.12.49.0/24	0.0.0.0	xe0	-	-	connected
20.20.20.0/24	0.0.0.0	xe2	-	-	connected
30.30.30.0/24	0.0.0.0	xe3	-	-	connected
40.40.40.0/24	10.10.10.2	xe1	30.30.30.2	xe3	ospf
50.50.50.0/24	10.10.10.2	xe1	30.30.30.2	xe3	ospf
60.60.60.0/24	10.10.10.2	xe1	30.30.30.2	xe3	ospf

PE1#show ldp fec

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 P - Primary route, B - LFA Backup route,
 R - Remote LFA Backup route,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	E >	non-existent	none	No	connected
2.2.2.2/32	NLB>	4.4.4.4	25608	No	30.30.30.2
	NL	3.3.3.3	25607	No	no nexthop
	NLP>	2.2.2.2	impl-null	No	10.10.10.2
3.3.3.3/32	NLB>	4.4.4.4	25609	No	30.30.30.2
	NLP>	2.2.2.2	25601	No	10.10.10.2
	NL	3.3.3.3	impl-null	No	no nexthop
4.4.4.4/32	NL	3.3.3.3	25608	No	no nexthop
	NLP>	2.2.2.2	25602	No	10.10.10.2
	NLB>	4.4.4.4	impl-null	No	30.30.30.2
5.5.5.5/32	NLB>	4.4.4.4	25610	No	30.30.30.2
	NLP>	2.2.2.2	25600	No	10.10.10.2
	NL	3.3.3.3	25600	No	no nexthop
10.10.10.0/24	NL	4.4.4.4	25611	No	connected
	NL	3.3.3.3	25610	No	connected
	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
10.12.49.0/24	NL	4.4.4.4	impl-null	No	connected
	NL	3.3.3.3	impl-null	No	connected
	NL	2.2.2.2	impl-null	No	connected

```

20.20.20.0/24      E >      non-existent      none      No      connected
                  NL      4.4.4.4      25612     No      connected
                  NL      2.2.2.2      25610     No      connected
                  NL      3.3.3.3      impl-null No      connected
30.30.30.0/24      E >      non-existent      none      No      connected
                  NL      3.3.3.3      25611     No      connected
                  NL      2.2.2.2      25611     No      connected
                  NL      4.4.4.4      impl-null No      connected
40.40.40.0/24      E >      non-existent      none      No      connected
                  NLB>    4.4.4.4      25613     No      30.30.30.2
                  NL      3.3.3.3      25612     No      no nexthop
                  NLP>    2.2.2.2      impl-null No      10.10.10.2
50.50.50.0/24      NLB>    4.4.4.4      25614     No      30.30.30.2
                  NLP>    2.2.2.2      25612     No      10.10.10.2
                  NL      3.3.3.3      impl-null No      no nexthop
60.60.60.0/24      NLP>    2.2.2.2      25609     No      10.10.10.2
                  NL      3.3.3.3      25609     No      no nexthop
                  NLB>    4.4.4.4      impl-null No      30.30.30.2

```

PE1#show ldp downstream

Codes: P - Primary route, B - Backup route

Session peer 5.5.5.5:

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
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Codes: P - Primary route, B - Backup route

Session peer 2.2.2.2:

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
50.50.50.0/24	10.10.10.2	Established	25612	0	
P					
30.30.30.0/24	connected	Established	25611	0	
20.20.20.0/24	connected	Established	25610	0	
4.4.4.4/32	10.10.10.2	Established	25602	0	
P					
3.3.3.3/32	10.10.10.2	Established	25601	0	
P					
60.60.60.0/24	10.10.10.2	Established	25609	0	
P					
5.5.5.5/32	10.10.10.2	Established	25600	0	
P					
40.40.40.0/24	10.10.10.2	Established	impl-null	0	
P					
10.12.49.0/24	connected	Established	impl-null	0	
10.10.10.0/24	connected	Established	impl-null	0	
2.2.2.2/32	10.10.10.2	Established	impl-null	0	
P					

Codes: P - Primary route, B - Backup route

Session peer 3.3.3.3:

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
40.40.40.0/24	connected	Established	25612	0	
30.30.30.0/24	connected	Established	25611	0	
10.10.10.0/24	connected	Established	25610	0	

4.4.4.4/32	connected	Established	25608	0
2.2.2.2/32	connected	Established	25607	0
60.60.60.0/24	connected	Established	25609	0
5.5.5.5/32	connected	Established	25600	0
50.50.50.0/24	connected	Established	impl-null	0
20.20.20.0/24	connected	Established	impl-null	0
10.12.49.0/24	connected	Established	impl-null	0
3.3.3.3/32	connected	Established	impl-null	0

Codes: P - Primary route, B - Backup route

Session peer 4.4.4.4:

FEC Code	NextHop Addr	State	Label	Req.ID	Attr
50.50.50.0/24	connected	Established	25614	0	
50.50.50.0/24	30.30.30.2	Established	25614	0	
B					
40.40.40.0/24	connected	Established	25613	0	
40.40.40.0/24	30.30.30.2	Established	25613	0	
B					
20.20.20.0/24	connected	Established	25612	0	
10.10.10.0/24	connected	Established	25611	0	
5.5.5.5/32	connected	Established	25610	0	
5.5.5.5/32	30.30.30.2	Established	25610	0	
B					
3.3.3.3/32	connected	Established	25609	0	
3.3.3.3/32	30.30.30.2	Established	25609	0	
B					
2.2.2.2/32	connected	Established	25608	0	
2.2.2.2/32	30.30.30.2	Established	25608	0	
B					
60.60.60.0/24	connected	Established	impl-null	0	
60.60.60.0/24	30.30.30.2	Established	impl-null	0	
B					
30.30.30.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
4.4.4.4/32	connected	Established	impl-null	0	
4.4.4.4/32	30.30.30.2	Established	impl-null	0	
B					

PE1#show ldp lsp

DOWNSTREAM LSP :

FEC Code	NextHop Addr	State	Label	Req.ID	Attr
1.1.1.1/32	connected	Established	none	0	None
2.2.2.2/32	connected	Established	25608	0	
2.2.2.2/32	30.30.30.2	Established	25608	0	
B					
2.2.2.2/32	connected	Established	25607	0	
2.2.2.2/32	10.10.10.2	Established	impl-null	0	
P					
3.3.3.3/32	connected	Established	25609	0	
3.3.3.3/32	30.30.30.2	Established	25609	0	
B					

P	3.3.3.3/32	10.10.10.2	Established	25601	0	
	3.3.3.3/32	connected	Established	impl-null	0	
	4.4.4.4/32	connected	Established	25608	0	
P	4.4.4.4/32	10.10.10.2	Established	25602	0	
	4.4.4.4/32	connected	Established	impl-null	0	
B	4.4.4.4/32	30.30.30.2	Established	impl-null	0	
	5.5.5.5/32	connected	Established	25610	0	
B	5.5.5.5/32	30.30.30.2	Established	25610	0	
P	5.5.5.5/32	10.10.10.2	Established	25600	0	
	5.5.5.5/32	connected	Established	25600	0	
	10.10.10.0/24	connected	Established	25611	0	
	10.10.10.0/24	connected	Established	25610	0	
	10.10.10.0/24	connected	Established	impl-null	0	
	10.10.10.0/24	connected	Established	none	0	None
	10.12.49.0/24	connected	Established	impl-null	0	
	10.12.49.0/24	connected	Established	impl-null	0	
	10.12.49.0/24	connected	Established	impl-null	0	
	10.12.49.0/24	connected	Established	none	0	None
	20.20.20.0/24	connected	Established	25612	0	
	20.20.20.0/24	connected	Established	25610	0	
	20.20.20.0/24	connected	Established	impl-null	0	
	20.20.20.0/24	connected	Established	none	0	None
	30.30.30.0/24	connected	Established	25611	0	
	30.30.30.0/24	connected	Established	25611	0	
	30.30.30.0/24	connected	Established	impl-null	0	
	30.30.30.0/24	connected	Established	none	0	None
	40.40.40.0/24	connected	Established	25613	0	
B	40.40.40.0/24	30.30.30.2	Established	25613	0	
	40.40.40.0/24	connected	Established	25612	0	
P	40.40.40.0/24	10.10.10.2	Established	impl-null	0	
	50.50.50.0/24	connected	Established	25614	0	
B	50.50.50.0/24	30.30.30.2	Established	25614	0	
P	50.50.50.0/24	10.10.10.2	Established	25612	0	
	50.50.50.0/24	connected	Established	impl-null	0	
P	60.60.60.0/24	10.10.10.2	Established	25609	0	
	60.60.60.0/24	connected	Established	25609	0	
	60.60.60.0/24	connected	Established	impl-null	0	
B	60.60.60.0/24	30.30.30.2	Established	impl-null	0	

UPSTREAM LSP :

FEC	State	Label	Req.ID	Attr
1.1.1.1/32	Established	impl-null	0	None

1.1.1.1/32	Established	impl-null	0	None
1.1.1.1/32	Established	impl-null	0	None
2.2.2.2/32	Established	25602	0	None
2.2.2.2/32	Established	25608	0	None
2.2.2.2/32	Established	25602	0	None
2.2.2.2/32	Established	25608	0	None
3.3.3.3/32	Established	25614	0	None
3.3.3.3/32	Established	25614	0	None
3.3.3.3/32	Established	25609	0	None
3.3.3.3/32	Established	25609	0	None
4.4.4.4/32	Established	25615	0	None
4.4.4.4/32	Established	25605	0	None
4.4.4.4/32	Established	25615	0	None
4.4.4.4/32	Established	25605	0	None
5.5.5.5/32	Established	25606	0	None
5.5.5.5/32	Established	25606	0	None
5.5.5.5/32	Established	25613	0	None
5.5.5.5/32	Established	25613	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
40.40.40.0/24	Established	25603	0	None
40.40.40.0/24	Established	25610	0	None
40.40.40.0/24	Established	25603	0	None
40.40.40.0/24	Established	25610	0	None
50.50.50.0/24	Established	25616	0	None
50.50.50.0/24	Established	25616	0	None
50.50.50.0/24	Established	25611	0	None
50.50.50.0/24	Established	25611	0	None
60.60.60.0/24	Established	25607	0	None
60.60.60.0/24	Established	25612	0	None
60.60.60.0/24	Established	25612	0	None
60.60.60.0/24	Established	25607	0	None

PE1#show ldp fec prefix 5.5.5.5/32

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 P - Primary route, B - LFA Backup route,
 R - Remote LFA Backup route,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
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5.5.5.5/32      NLB>    4.4.4.4      25610      No    30.30.30.2
                  NLP>    2.2.2.2      25600      No    10.10.10.2
                  NL      3.3.3.3      25600      No    no nexthop

```

PE1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2					
			13	-	No	LSP_DEFAULT	25608
xe3	No	30.30.30.2					
L>	3.3.3.3/32	3	9	-	Yes	LSP_DEFAULT	25601
xe1	No	10.10.10.2					
			14	-	No	LSP_DEFAULT	25609
xe3	No	30.30.30.2					
L>	4.4.4.4/32	5	10	-	Yes	LSP_DEFAULT	25602
xe1	No	10.10.10.2					
			15	-	No	LSP_DEFAULT	3
xe3	No	30.30.30.2					
L>	5.5.5.5/32	7	7	-	Yes	LSP_DEFAULT	25600
xe1	No	10.10.10.2					
			16	-	No	LSP_DEFAULT	25610
xe3	No	30.30.30.2					
L>	40.40.40.0/24	2	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2					
			17	-	No	LSP_DEFAULT	25613
xe3	No	30.30.30.2					
L>	50.50.50.0/24	4	11	-	Yes	LSP_DEFAULT	25612
xe1	No	10.10.10.2					
			18	-	No	LSP_DEFAULT	25614
xe3	No	30.30.30.2					
L>	60.60.60.0/24	6	8	-	Yes	LSP_DEFAULT	25609
xe1	No	10.10.10.2					
			15	-	No	LSP_DEFAULT	3
xe3	No	30.30.30.2					

PE1#show mpls forwarding-table 5.5.5.5/32

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	5.5.5.5/32	7	7	-	Yes	LSP_DEFAULT	25600
xe1	No	10.10.10.2					
			16	-	No	LSP_DEFAULT	25610
xe3	No	30.30.30.2					

PE1#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 13

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 13, owner: LDP, Stale: NO, out intf: xe3, out label: 25608

Nexthop addr: 30.30.30.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 9

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25601

Nexthop addr: 10.10.10.2 cross connect ix: 5, op code: Push

Backup Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 14

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 14, owner: LDP, Stale: NO, out intf: xe3, out label: 25609

Nexthop addr: 30.30.30.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 10

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 10, owner: LDP, Stale: NO, out intf: xe1, out label: 25602

Nexthop addr: 10.10.10.2 cross connect ix: 6, op code: Push

Backup Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 15

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 15, owner: N/A, Stale: NO, out intf: xe3, out label: 3

Nexthop addr: 30.30.30.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
Nexthop addr: 10.10.10.2 cross connect ix: 2, op code: Push

Backup Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 16
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 16, owner: LDP, Stale: NO, out intf: xe3, out label: 25610
Nexthop addr: 30.30.30.2 cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 17
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 17, owner: LDP, Stale: NO, out intf: xe3, out label: 25613
Nexthop addr: 30.30.30.2 cross connect ix: 8, op code: Push

Primary FTN entry with FEC: 50.50.50.0/24, id: 4, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 11
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25612
Nexthop addr: 10.10.10.2 cross connect ix: 7, op code: Push

Backup Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 18
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 18, owner: LDP, Stale: NO, out intf: xe3, out label: 25614
Nexthop addr: 30.30.30.2 cross connect ix: 10, op code: Push

Primary FTN entry with FEC: 60.60.60.0/24, id: 6, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609

Nexthop addr: 10.10.10.2 cross connect ix: 8, op code: Push

Backup Cross connect ix: 12, in intf: - in label: 0 out-segment ix: 15

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 15, owner: N/A, Stale: NO, out intf: xe3, out label: 3

Nexthop addr: 30.30.30.2 cross connect ix: 4, op code: Push

PE1#show mpls ftn-table 5.5.5.5/32

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25600

Nexthop addr: 10.10.10.2 cross connect ix: 2, op code: Push

Backup Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 16

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 16, owner: LDP, Stale: NO, out intf: xe3, out label: 25610

Nexthop addr: 30.30.30.2 cross connect ix: 6, op code: Push

PE1#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup

K - CLI ILM, T - MPLS-TP, s - Stitched ILM

S - SNMP, L - LDP, R - RSVP, C - CRLDP

B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT

O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI

P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
Nexthop		pri	LSP-			
Type						
L>	2.2.2.2/32	9		25608	3	N/A
10.10.10.2		Yes	LSP_			xe1
DEFAULT						
L>	4.4.4.4/32	6		25605	25602	N/A
10.10.10.2		Yes	LSP_			xe1
DEFAULT						
				25605	3	N/A
30.30.30.2		No	LSP_			xe3

DEFAULT						
L> 2.2.2.2/32	3		25602	3	N/A	xe1
10.10.10.2	Yes	LSP_				
DEFAULT						
30.30.30.2	No	LSP_	25602	25608	N/A	xe3
DEFAULT						
L> 40.40.40.0/24	4		25603	3	N/A	xe1
10.10.10.2	Yes	LSP_				
DEFAULT						
30.30.30.2	No	LSP_	25603	25613	N/A	xe3
DEFAULT						
L> 5.5.5.5/32	7		25606	25600	N/A	xe1
10.10.10.2	Yes	LSP_				
DEFAULT						
30.30.30.2	No	LSP_	25606	25610	N/A	xe3
DEFAULT						
L> 60.60.60.0/24	8		25607	25609	N/A	xe1
10.10.10.2	Yes	LSP_				
DEFAULT						
30.30.30.2	No	LSP_	25607	3	N/A	xe3
DEFAULT						
L> 60.60.60.0/24	13		25612	25609	N/A	xe1
10.10.10.2	Yes	LSP_				
DEFAULT						
L> 40.40.40.0/24	11		25610	3	N/A	xe1
10.10.10.2	Yes	LSP_				
DEFAULT						
L> 3.3.3.3/32	10		25609	25601	N/A	xe1
10.10.10.2	Yes	LSP_				
DEFAULT						
L> 50.50.50.0/24	12		25611	25612	N/A	xe1
10.10.10.2	Yes	LSP_				
DEFAULT						
L> 3.3.3.3/32	15		25614	25601	N/A	xe1
10.10.10.2	Yes	LSP_				
DEFAULT						
30.30.30.2	No	LSP_	25614	25609	N/A	xe3
DEFAULT						
L> 5.5.5.5/32	14		25613	25600	N/A	xe1
10.10.10.2	Yes	LSP_				
DEFAULT						
L> 4.4.4.4/32	16		25615	25602	N/A	xe1
10.10.10.2	Yes	LSP_				
DEFAULT						
L> 50.50.50.0/24	17		25616	25612	N/A	xe1
10.10.10.2	Yes	LSP_				
DEFAULT						
30.30.30.2	No	LSP_	25616	25614	N/A	xe3

DEFAULT

PE1#show ip ospf neighbor

Total number of full neighbors: 3

OSPF process 1 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	
Instance ID						
2.2.2.2	1	Full/Backup	00:00:34	10.10.10.2	xe1	0
3.3.3.3	1	Full/Backup	00:00:31	20.20.20.2	xe2	0
4.4.4.4	1	Full/Backup	00:00:32	30.30.30.2	xe3	0

PE1#show ip ospf interface brief

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
lo	1	0.0.0.0	1	1	Loopback	0	Up

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
xe1	1	0.0.0.0	4	10	DR	1	Up

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
xe2	1	0.0.0.0	14	15	DR	1	Up

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
xe3	1	0.0.0.0	15	20	DR	1	Up

PE1#show ip ospf database

OSPF Router with ID (1.1.1.1) (Process ID 1 VRF default)

Router Link States (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum	Link count
1.1.1.1	1.1.1.1	961	0x8000000f	0x5af3	4
2.2.2.2	2.2.2.2	992	0x80000009	0x5f60	3
3.3.3.3	3.3.3.3	918	0x80000009	0x62d8	3
4.4.4.4	4.4.4.4	913	0x80000009	0x6551	3
5.5.5.5	5.5.5.5	994	0x80000005	0xd45c	4

Net Link States (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum
10.10.10.1	1.1.1.1	1401	0x80000002	0x9277
20.20.20.1	1.1.1.1	1621	0x80000002	0x5b8c
30.30.30.1	1.1.1.1	1541	0x80000002	0x24a1
40.40.40.1	2.2.2.2	422	0x80000002	0xf0aa
50.50.50.1	3.3.3.3	1088	0x80000002	0x8be9
60.60.60.1	4.4.4.4	1083	0x80000002	0x2629

Area-Local Opaque-LSA (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum	Opaque ID
1.0.0.1	1.1.1.1	1041	0x80000004	0x2af9	1
1.0.0.1	2.2.2.2	942	0x80000003	0x30ec	1
1.0.0.1	3.3.3.3	948	0x80000004	0x32e1	1
1.0.0.1	4.4.4.4	953	0x80000004	0x36d5	1
1.0.0.1	5.5.5.5	1474	0x80000002	0x3ec7	1
1.0.0.8	4.4.4.4	1193	0x80000002	0x7938	8
1.0.0.8	5.5.5.5	464	0x80000002	0x7933	8
1.0.0.10	1.1.1.1	1181	0x80000003	0xd806	10
1.0.0.10	2.2.2.2	1182	0x80000003	0x8161	10
1.0.0.12	3.3.3.3	958	0x80000003	0xc725	12
1.0.0.12	5.5.5.5	994	0x80000003	0xa93a	12
1.0.0.22	2.2.2.2	912	0x80000003	0xdb47	22
1.0.0.22	5.5.5.5	934	0x80000003	0x9f76	22
1.0.0.30	1.1.1.1	1051	0x80000003	0x7415	30
1.0.0.30	3.3.3.3	1058	0x80000003	0x404e	30
1.0.0.32	1.1.1.1	961	0x80000003	0xc481	32
1.0.0.32	4.4.4.4	1013	0x80000003	0xb398	32

PE1#show ip route summary

IP routing table name is Default-IP-Routing-Table(0)

IP routing table maximum-paths : 8
Total number of IPv4 routes : 14
Total number of IPv4 paths : 14
Pending routes (due to route max reached): 0
Route Source Networks
kernel 1
connected 6
ospf 7
Total 14
FIB 14

ECMP statistics (active in ASIC):
Total number of IPv4 ECMP routes : 0
Total number of IPv4 ECMP paths : 0

LFA Non ECMP statistics

Total number of Routes : 7
Total number of Primary Paths : 7
Total number of Backup Paths : 7

PE1#show ip interface brief

'*' - address is assigned by dhcp client

Interface	IP-Address	Admin-Status	Link-Status
-----------	------------	--------------	-------------

```

xe0          *10.12.49.172    up          up
xe1          unassigned       up          up
xe1          10.10.10.1       up          up
xe3          unassigned       up          up
xe4          unassigned       up          up
xe5          unassigned       up          up
xe6          unassigned       up          up
xe7          unassigned       up          up
xe8          unassigned       up          up
xe9          unassigned       up          up
xe10         unassigned       up          up
xe11         unassigned       up          up
xe2          20.20.20.1       up          up
xe3          30.30.30.1       up          up
lo           127.0.0.1        up          up

```

```
PE1#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
5.5.5.5	xe2	Passive	OPERATIONAL	30	00:45:56
2.2.2.2	xe1	Passive	OPERATIONAL	30	00:49:24
3.3.3.3	xe2	Passive	OPERATIONAL	30	00:47:18
4.4.4.4	xe3	Passive	OPERATIONAL	30	00:46:33

```
PE1#show ip route
```

```

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

```

```
IP Route Table for VRF "default"
```

```
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
```

```

K*      0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C       1.1.1.1/32 is directly connected, lo, 00:55:17
O       2.2.2.2/32 [110/11] via 10.10.10.2, xe1, 00:49:29
O       3.3.3.3/32 [110/13] via 10.10.10.2, xe1, 00:46:16
O       4.4.4.4/32 [110/13] via 10.10.10.2, xe1, 00:46:16
O       5.5.5.5/32 [110/12] via 10.10.10.2, xe1, 00:46:18
C       10.10.10.0/24 is directly connected, xe1, 00:53:26
C       10.12.49.0/24 is directly connected, xe0, 17:05:26
C       20.20.20.0/24 is directly connected, xe2, 00:53:26
C       30.30.30.0/24 is directly connected, xe3, 00:53:26
O       40.40.40.0/24 [110/11] via 10.10.10.2, xe1, 00:46:18
O       50.50.50.0/24 [110/12] via 10.10.10.2, xe1, 00:46:16
O       60.60.60.0/24 [110/12] via 10.10.10.2, xe1, 00:46:16
C       127.0.0.0/8 is directly connected, lo, 17:19:02

```

```
PE1#show ldp routes
```

Prefix Addr	Nexthop Addr	Intf	Backup Addr	Backup Intf	Owner
0.0.0.0/0	10.12.49.1	xe0	-	-	kernel
1.1.1.1/32	0.0.0.0	lo	-	-	connected
2.2.2.2/32	10.10.10.2	xe1	30.30.30.2	xe3	ospf
3.3.3.3/32	10.10.10.2	xe1	30.30.30.2	xe3	ospf
4.4.4.4/32	10.10.10.2	xe1	30.30.30.2	xe3	ospf
5.5.5.5/32	10.10.10.2	xe1	30.30.30.2	xe3	ospf
10.10.10.0/24	0.0.0.0	xe1	-	-	connected
10.12.49.0/24	0.0.0.0	xe0	-	-	connected
20.20.20.0/24	0.0.0.0	xe2	-	-	connected
30.30.30.0/24	0.0.0.0	xe3	-	-	connected
40.40.40.0/24	10.10.10.2	xe1	30.30.30.2	xe3	ospf
50.50.50.0/24	10.10.10.2	xe1	30.30.30.2	xe3	ospf
60.60.60.0/24	10.10.10.2	xe1	30.30.30.2	xe3	ospf

```
PE1#show mpls forwarding-table
```

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2					
			13	-	No	LSP_DEFAULT	25608
xe3	No	30.30.30.2					
L>	3.3.3.3/32	3	9	-	Yes	LSP_DEFAULT	25601
xe1	No	10.10.10.2					
			14	-	No	LSP_DEFAULT	25609
xe3	No	30.30.30.2					
L>	4.4.4.4/32	5	10	-	Yes	LSP_DEFAULT	25602
xe1	No	10.10.10.2					
			15	-	No	LSP_DEFAULT	3
xe3	No	30.30.30.2					
L>	5.5.5.5/32	7	7	-	Yes	LSP_DEFAULT	25600
xe1	No	10.10.10.2					
			16	-	No	LSP_DEFAULT	25610
xe3	No	30.30.30.2					
L>	40.40.40.0/24	2	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2					
			17	-	No	LSP_DEFAULT	25613
xe3	No	30.30.30.2					
L>	50.50.50.0/24	4	11	-	Yes	LSP_DEFAULT	25612
xe1	No	10.10.10.2					
			18	-	No	LSP_DEFAULT	25614
xe3	No	30.30.30.2					
L>	60.60.60.0/24	6	8	-	Yes	LSP_DEFAULT	25609
xe1	No	10.10.10.2					
			15	-	No	LSP_DEFAULT	3
xe3	No	30.30.30.2					

```
PE1#show mpls forwarding-table 5.5.5.5/32
```

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nextthop					
L>	5.5.5.5/32	7	7	-	Yes	LSP_DEFAULT	25600
xe1	No	10.10.10.2					
			16	-	No	LSP_DEFAULT	25610
xe3	No	30.30.30.2					

PE1#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
 K - CLI ILM, T - MPLS-TP, s - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF	Nextthop	pri	LSP-
Type									
L>	2.2.2.2/32	9	25608	3	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
L>	4.4.4.4/32	6	25605	25602	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
			25605	3	N/A	xe3	30.30.30.2	No	LSP_
DEFAULT									
L>	2.2.2.2/32	3	25602	3	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
			25602	25608	N/A	xe3	30.30.30.2	No	LSP_
DEFAULT									
L>	40.40.40.0/24	4	25603	3	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
			25603	25613	N/A	xe3	30.30.30.2	No	LSP_
DEFAULT									
L>	5.5.5.5/32	7	25606	25600	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
			25606	25610	N/A	xe3	30.30.30.2	No	LSP_
DEFAULT									
L>	60.60.60.0/24	8	25607	25609	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
			25607	3	N/A	xe3	30.30.30.2	No	LSP_
DEFAULT									
L>	60.60.60.0/24	13	25612	25609	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
L>	40.40.40.0/24	11	25610	3	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
L>	3.3.3.3/32	10	25609	25601	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
L>	50.50.50.0/24	12	25611	25612	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
L>	3.3.3.3/32	15	25614	25601	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
			25614	25609	N/A	xe3	30.30.30.2	No	LSP_
DEFAULT									
L>	5.5.5.5/32	14	25613	25600	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
L>	4.4.4.4/32	16	25615	25602	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
L>	50.50.50.0/24	17	25616	25612	N/A	xe1	10.10.10.2	Yes	LSP_
DEFAULT									
			25616	25614	N/A	xe3	30.30.30.2	No	LSP_
DEFAULT									

LDP-FRR with ISIS as IGP Configuration

Below are the configurations and validations involving NSM, ISIS, LDP before configuring fast-reroute for IGP and LDP.

PE1

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1
(config-router)#transport-address ipv4 1.1.1.1 0	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 5.5.5.5	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.10.10.1/24	Configure IPv4 address for xe1.
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe1.
(config-if)#isis wide-metric 20 level-1	Assign isis wide-metric to the interface
(config-if)#mpls ldp-igp sync isis level-1	Configure LDP-IGP Synchronization for interface xe1 belonging to an IS-IS process with corresponding IS-IS level. The values level-1 level-2-only level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 20.20.20.1/24	Configure IPv4 address for xe2
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe2.
(config-if)#isis wide-metric 15 level-1	Assign isis wide-metric to the interface

(config-if)#mpls ldp-igp sync isis level-1	Configure LDP-IGP Synchronization for interface xe2 belonging to an IS-IS process with corresponding IS-IS level. The values level-1 level-2-only level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
(config-if)#exit	Exit interface mode
(config)#interface xe3	Enter interface mode.
(config-if)#ip address 30.30.30.1/24	Configure IPv4 address for xe3
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#label-switching	Enable label switching on interface xe3
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe3
(config-if)#isis wide-metric 60 level-1	Assign isis wide-metric to the interface
(config-if)#mpls ldp-igp sync isis level-1	Configure LDP-IGP Synchronization for interface xe3 belonging to an IS-IS process with corresponding IS-IS level. The values level-1 level-2-only level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
(config-if)#exit	Exit interface mode
(config)#router isis 1	Create an IS-IS routing instance for area 49 with instance 1
(config-router)#net 49.0001.0000.0000.0001.00	Establish a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)#bfd all-interfaces	Enable BFD for ISIS on all interfaces
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-if)#exit	Exit interface mode.
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#commit	Commit all the configurations

P1

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.

(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2
(config-router)#transport-address ipv4 2.2.2.2 0	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.10.10.2/24	Configure IPv4 address for xe1.
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe1.
(config-if)#mpls ldp-igp sync isis level-1	Configure LDP-IGP Synchronization for interface xe1 belonging to an IS-IS process with corresponding IS-IS level. The values level-1 level-2-only level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 40.40.40.1/24	Configure IPv4 address for xe2
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe2.
(config-if)#mpls ldp-igp sync isis level-1	Configure LDP-IGP Synchronization for interface xe2 belonging to an IS-IS process with corresponding IS-IS level. The values level-1 level-2-only level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
(config-if)#exit	Exit interface mode
(config)#router isis 1	Create an IS-IS routing instance for area 49 with instance 1
(config-router)#net 49.0001.0000.0000.0002.00	Establish a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)#bfd all-interfaces	Enable BFD for ISIS on all interfaces
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-if)#exit	Exit interface mode.

(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#commit	Commit all the configurations

P2

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 3.3.3.3	Set the router ID to IP address 3.3.3.3
(config-router)#transport-address ipv4 3.3.3.3 0	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 20.20.20.2/24	Configure IPv4 address for xe1.
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe1.
(config-if)#mpls ldp-igp sync isis level-1	Configure LDP-IGP Synchronization for interface xe1 belonging to an IS-IS process with corresponding IS-IS level. The values level-1 level-2-only level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 50.50.50.1/24	Configure IPv4 address for xe2
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe2.
(config-if)#mpls ldp-igp sync isis level-1	Configure LDP-IGP Synchronization for interface xe2 belonging to an IS-IS process with corresponding IS-IS level. The values level-1 level-2-only level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.

(config-if)#exit	Exit interface mode
(config)#router isis 1	Create an IS-IS routing instance for area 49 with instance 1
(config-router)#net 49.0001.0000.0000.0003.00	Establish a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)#bfd all-interfaces	Enable BFD for ISIS on all interfaces
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-if)#exit	Exit interface mode.
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#commit	Commit all the configurations

P3

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 4.4.4.4/32 secondary	Set the IP address of the loopback interface to 4.4.4.4/32
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 4.4.4.4	Set the router ID to IP address 4.4.4.4
(config-router)#transport-address ipv4 4.4.4.4 0	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 30.30.30.2/24	Configure IPv4 address for xe1.
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe1.
(config-if)#mpls ldp-igp sync isis level-1	Configure LDP-IGP Synchronization for interface xe1 belonging to an IS-IS process with corresponding IS-IS level. The values level-1 level-2-only level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode.

(config-if)#ip address 60.60.60.1/24	Configure IPv4 address for xe2
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe2.
(config-if)#mpls ldp-igp sync isis level-1	Configure LDP-IGP Synchronization for interface xe2 belonging to an IS-IS process with corresponding IS-IS level. The values level-1 level-2-only level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
(config-if)#exit	Exit interface mode
(config)#router isis 1	Create an IS-IS routing instance for area 49 with instance 1
(config-router)#net 49.0001.0000.0000.0004.00	Establish a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)#bfd all-interfaces	Enable BFD for ISIS on all interfaces
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-if)#exit	Exit interface mode.
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#commit	Commit all the configurations

PE2

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 5.5.5.5/32 secondary	Set the IP address of the loopback interface to 5.5.5.5/32
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 5.5.5.5	Set the router ID to IP address 5.5.5.5
(config-router)#transport-address ipv4 5.5.5.5 0	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode.

(config-if)#ip address 40.40.40.2/24	Configure IPv4 address for xe1.
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe1.
(config-if)#mpls ldp-igp sync isis level-1	Configure LDP-IGP Synchronization for interface xe1 belonging to an IS-IS process with corresponding IS-IS level. The values level-1 level-2-only level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 50.50.50.2/24	Configure IPv4 address for xe2
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe2.
(config-if)#mpls ldp-igp sync isis level-1	Configure LDP-IGP Synchronization for interface xe2 belonging to an IS-IS process with corresponding IS-IS level. The values level-1 level-2-only level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
(config-if)#exit	Exit interface mode
(config)#interface xe3	Enter interface mode.
(config-if)#ip address 60.60.60.2/24	Configure IPv4 address for xe3
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#label-switching	Enable label switching on interface xe3
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe3
(config-if)#mpls ldp-igp sync isis level-1	Configure LDP-IGP Synchronization for interface xe3 belonging to an IS-IS process with corresponding IS-IS level. The values level-1 level-2-only level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
(config-if)#exit	Exit interface mode
(config)#router isis 1	Create an IS-IS routing instance for area 49 with instance 1
(config-router)#net 49.0001.0000.0000.0005.00	Establish a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance

(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)#bfd all-interfaces	Enable BFD for ISIS on all interfaces
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-if)#exit	Exit interface mode.
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#commit	Commit all the configurations

Validation

PE1#show clns neighbors

Total number of L1 adjacencies: 3

Total number of L2 adjacencies: 0

Total number of adjacencies: 3

Tag 1: VRF : default

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
P1	xe1	5254.0002.5b0a	Up	28	L1	IS-IS
P2	xe2	5254.009b.f9a2	Up	6	L1	IS-IS
P3	xe3	5254.005d.e995	Up	8	L1	IS-IS

PE1#show clns neighbors detail

Total number of L1 adjacencies: 3

Total number of L2 adjacencies: 0

Total number of adjacencies: 3

Tag 1: VRF : default

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
P1	xe1	5254.0002.5b0a	Up	25	L1	IS-IS

L1 Adjacency ID: 1

L2 Adjacency ID: 2

Uptime: 00:14:43

Area Address(es): 49.0001

IP Address(es): 10.10.10.2

Level-1 Protocols Supported: IPv4

Bidirectional Forwarding Detection is enabled

Adjacency advertisement: Advertise

P2	xe2	5254.009b.f9a2	Up	7	L1	IS-IS
----	-----	----------------	----	---	----	-------

L1 Adjacency ID: 1

L2 Adjacency ID: 2

Uptime: 00:14:19

Area Address(es): 49.0001

IP Address(es): 20.20.20.2

Level-1 Protocols Supported: IPv4

Bidirectional Forwarding Detection is enabled

Adjacency advertisement: Advertise


```

P3          xe3          5254.005d.e995      Up      5          L1      IS-IS
L1 Adjacency ID: 1
L2 Adjacency ID: 2
Uptime: 00:13:54
Area Address(es): 49.0001
IP Address(es): 30.30.30.2
Level-1 Protocols Supported: IPv4
Bidirectional Forwarding Detection is enabled
Adjacency advertisement: Advertise

```

```
PE1#show isis database
```

```
Tag 1: VRF : default
```

```
IS-IS Level-1 Link State Database:
```

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
PE1.00-00	* 0x0000000A	0xDB9F	379	0/0/0
PE1.02-00	* 0x00000001	0x8843	319	0/0/0
P1.00-00	0x00000008	0xC257	446	0/0/0
P1.03-00	0x00000001	0xBE07	406	0/0/0
P2.00-00	0x00000007	0x0352	450	0/0/0
P2.02-00	0x00000001	0x7652	342	0/0/0
P2.03-00	0x00000001	0xBF04	436	0/0/0
P3.00-00	0x00000007	0xE1AE	471	0/0/0
P3.02-00	0x00000001	0x774F	357	0/0/0
PE2.00-00	0x0000000A	0xE3FE	467	0/0/0
PE2.04-00	0x00000001	0xA619	466	0/0/0

```
PE1#show isis database verbose
```

```
Tag 1: VRF : default
```

```
IS-IS Level-1 Link State Database:
```

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
PE1.00-00	* 0x0000000A	0xDB9F	369	0/0/0

```

Area Address: 49.0001
NLPID:       0xCC
Hostname:    PE1
IP Address:  1.1.1.1
Router ID:   10.12.49.172
Metric:      20          IS-Extended PE1.02
IPv4 Interface Address: 10.10.10.1
Neighbor IP Address: 10.10.10.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec

```

```

TE-Default Metric: 20
Metric: 15          IS-Extended P2.02
IPv4 Interface Address: 20.20.20.1
Neighbor IP Address: 20.20.20.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 15
Metric: 60          IS-Extended P3.02
IPv4 Interface Address: 30.30.30.1
Neighbor IP Address: 30.30.30.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 60
Metric: 10          IP-Extended 1.1.1.1/32
Metric: 20          IP-Extended 10.10.10.0/24
Metric: 15          IP-Extended 20.20.20.0/24
Metric: 60          IP-Extended 30.30.30.0/24
PE1.02-00          * 0x00000001  0x8843          309          0/0/0
Metric: 0          IS-Extended PE1.00
Metric: 0          IS-Extended P1.00
P1.00-00          0x00000008  0xC257          436          0/0/0
Area Address: 49.0001
NLPID: 0xCC
Hostname: P1
IP Address: 2.2.2.2
Router ID: 10.12.49.173
Metric: 10          IS-Extended PE1.02
IPv4 Interface Address: 10.10.10.2
Neighbor IP Address: 10.10.10.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:

```

```

Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IS-Extended P1.03
IPv4 Interface Address: 40.40.40.1
Neighbor IP Address: 40.40.40.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IP-Extended 2.2.2.2/32
Metric: 10          IP-Extended 10.10.10.0/24
Metric: 10          IP-Extended 40.40.40.0/24
P1.03-00            0x00000001  0xBE07          396          0/0/0
Metric: 0           IS-Extended P1.00
Metric: 0           IS-Extended PE2.00
P2.00-00            0x00000007  0x0352          440          0/0/0
Area Address: 49.0001
NLPID: 0xCC
Hostname: P2
IP Address: 3.3.3.3
Router ID: 10.12.49.176
Metric: 10          IS-Extended P2.02
IPv4 Interface Address: 20.20.20.2
Neighbor IP Address: 20.20.20.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec

```

```
TE-Default Metric: 10
Metric: 10          IS-Extended P2.03
IPv4 Interface Address: 50.50.50.1
Neighbor IP Address: 50.50.50.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IP-Extended 3.3.3.3/32
Metric: 10          IP-Extended 50.50.50.0/24
Metric: 10          IP-Extended 20.20.20.0/24
P2.02-00            0x00000001  0x7652          332          0/0/0
Metric: 0           IS-Extended P2.00
Metric: 0           IS-Extended PE1.00
P2.03-00            0x00000001  0xBF04          426          0/0/0
Metric: 0           IS-Extended P2.00
Metric: 0           IS-Extended PE2.00
P3.00-00            0x00000007  0xE1AE          461          0/0/0
Area Address: 49.0001
NLPID: 0xCC
Hostname: P3
IP Address: 4.4.4.4
Router ID: 10.12.49.177
Metric: 10          IS-Extended P3.02
IPv4 Interface Address: 30.30.30.2
Neighbor IP Address: 30.30.30.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IS-Extended PE2.04
IPv4 Interface Address: 60.60.60.1
Neighbor IP Address: 60.60.60.2
Maximum Link Bandwidth : 100000.00 kbits/sec
```

```
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10      IP-Extended 4.4.4.4/32
Metric: 10      IP-Extended 60.60.60.0/24
Metric: 10      IP-Extended 30.30.30.0/24
P3.02-00      0x00000001  0x774F      347      0/0/0
Metric: 0      IS-Extended P3.00
Metric: 0      IS-Extended PE1.00
PE2.00-00      0x0000000A  0xE3FE      457      0/0/0
Area Address: 49.0001
NLPID: 0xCC
Hostname: PE2
IP Address: 5.5.5.5
Router ID: 10.12.49.174
Metric: 10      IS-Extended P1.03
IPv4 Interface Address: 40.40.40.2
Neighbor IP Address: 40.40.40.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10      IS-Extended P2.03
IPv4 Interface Address: 50.50.50.2
Neighbor IP Address: 50.50.50.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
```

```

    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric:    10          IS-Extended PE2.04
IPv4 Interface Address: 60.60.60.2
Neighbor IP Address: 60.60.60.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric:    10          IP-Extended 5.5.5.5/32
Metric:    10          IP-Extended 60.60.60.0/24
Metric:    10          IP-Extended 50.50.50.0/24
Metric:    10          IP-Extended 40.40.40.0/24
PE2.04-00      0x00000001    0xA619          456          0/0/0
Metric:    0          IS-Extended PE2.00
Metric:    0          IS-Extended P3.00

PE1#show ldp session
Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
5.5.5.5              xe3        Passive    OPERATIONAL 30      00:12:46
2.2.2.2              xe1        Passive    OPERATIONAL 30      00:14:48
3.3.3.3              xe2        Passive    OPERATIONAL 30      00:14:00
4.4.4.4              xe3        Passive    OPERATIONAL 30      00:14:07

PE1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*          0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C           1.1.1.1/32 is directly connected, lo, 00:23:10
i L1        2.2.2.2/32 [115/30] via 10.10.10.2, xe1, 00:15:11

```

```

i L1      3.3.3.3/32 [115/25] via 20.20.20.2, xe2, 00:13:41
i L1      4.4.4.4/32 [115/45] via 20.20.20.2, xe2, 00:12:01
i L1      5.5.5.5/32 [115/35] via 20.20.20.2, xe2, 00:12:51
C         10.10.10.0/24 is directly connected, xe1, 00:23:10
C         10.12.49.0/24 is directly connected, xe0, 00:27:49
C         20.20.20.0/24 is directly connected, xe2, 00:23:10
C         30.30.30.0/24 is directly connected, xe3, 00:23:10
i L1      40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 00:12:51
i L1      50.50.50.0/24 [115/25] via 20.20.20.2, xe2, 00:12:51
i L1      60.60.60.0/24 [115/35] via 20.20.20.2, xe2, 00:12:51
C         127.0.0.0/8 is directly connected, lo, 02:59:00

```

PE1#show ip route summary

```

-----
IP routing table name is Default-IP-Routing-Table(0)
-----

```

```

IP routing table maximum-paths      : 8
Total number of IPv4 routes         : 14
Total number of IPv4 paths          : 14
Pending routes (due to route max reached): 0
Route Source      Networks
kernel            1
connected         6
isis              7
Total             14
FIB               14

```

ECMP statistics (active in ASIC):

```

Total number of IPv4 ECMP routes : 0
Total number of IPv4 ECMP paths  : 0

```

PE1#show ip interface brief

'*' - address is assigned by dhcp client

Interface	IP-Address	Admin-Status	Link-Status
xe0	*10.12.49.172	up	up
xe1	unassigned	up	up
xe1	10.10.10.1	up	up
xe3	unassigned	up	up
xe4	unassigned	up	up
xe5	unassigned	up	up
xe6	unassigned	up	up
xe7	unassigned	up	up
xe8	unassigned	up	up
xe9	unassigned	up	up
xe10	unassigned	up	up
xe11	unassigned	up	up
xe2	20.20.20.1	up	up

```
xe3          30.30.30.1      up          up
lo           127.0.0.1      up          up
```

```
PE1#show ip isis route fast-reroute
```

```
Tag   : 1   VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        D - discard, LP - Link Protecting, NP - Node Protecting,
        BP - Broadcast Interface Disjoint, Pri - Primary Path,
        Sec - Secondary Path, DP - Downstream Path
```

```
PE1#show ldp routes
```

Prefix Addr	Nexthop Addr	Intf	Owner
0.0.0.0/0	10.12.49.1	xe0	kernel
1.1.1.1/32	0.0.0.0	lo	connected
2.2.2.2/32	10.10.10.2	xe1	isis
3.3.3.3/32	20.20.20.2	xe2	isis
4.4.4.4/32	20.20.20.2	xe2	isis
5.5.5.5/32	20.20.20.2	xe2	isis
10.10.10.0/24	0.0.0.0	xe1	connected
10.12.49.0/24	0.0.0.0	xe0	connected
20.20.20.0/24	0.0.0.0	xe2	connected
30.30.30.0/24	0.0.0.0	xe3	connected
40.40.40.0/24	10.10.10.2	xe1	isis
50.50.50.0/24	20.20.20.2	xe2	isis
60.60.60.0/24	20.20.20.2	xe2	isis

```
PE1#show ldp fec
```

```
LSR codes   : E/N - LSR is egress/non-egress for this FEC,
              L - LSR received a label for this FEC,
              > - LSR will use this route for the FEC
```

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	E >	non-existent	none	No	connected
2.2.2.2/32	NL	4.4.4.4	25608	No	no nexthop
	NL	3.3.3.3	25608	No	no nexthop
	NL>	2.2.2.2	impl-null	No	10.10.10.2
3.3.3.3/32	NL	2.2.2.2	25608	No	no nexthop
	NL	4.4.4.4	25609	No	no nexthop
	NL>	3.3.3.3	impl-null	No	20.20.20.2
4.4.4.4/32	NL	2.2.2.2	25609	No	no nexthop
	NL>	3.3.3.3	25609	No	20.20.20.2
	NL	4.4.4.4	impl-null	No	no nexthop
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NL>	3.3.3.3	25610	No	20.20.20.2
	NL	2.2.2.2	25600	No	no nexthop
10.10.10.0/24	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
10.12.49.0/24	NL	3.3.3.3	impl-null	No	connected
	NL	4.4.4.4	impl-null	No	connected
	NL	2.2.2.2	impl-null	No	connected

20.20.20.0/24	E >	non-existent	none	No	connected
	NL	3.3.3.3	impl-null	No	connected
30.30.30.0/24	E >	non-existent	none	No	connected
	NL	2.2.2.2	25610	No	connected
	NL	3.3.3.3	25611	No	connected
40.40.40.0/24	NL	4.4.4.4	impl-null	No	connected
	E >	non-existent	none	No	connected
	NL	4.4.4.4	25611	No	no nexthop
	NL	3.3.3.3	25612	No	no nexthop
50.50.50.0/24	NL>	2.2.2.2	impl-null	No	10.10.10.2
	NL	2.2.2.2	25611	No	no nexthop
	NL	4.4.4.4	25612	No	no nexthop
	NL>	3.3.3.3	impl-null	No	20.20.20.2
60.60.60.0/24	NL	2.2.2.2	25612	No	no nexthop
	NL>	3.3.3.3	25613	No	20.20.20.2
	NL	4.4.4.4	impl-null	No	no nexthop

PE1#show ldp downstream

Session peer 5.5.5.5:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
-----	--------------	-------	-------	--------	------

Session peer 2.2.2.2:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
60.60.60.0/24	connected	Established	25612	0	
50.50.50.0/24	connected	Established	25611	0	
30.30.30.0/24	connected	Established	25610	0	
4.4.4.4/32	connected	Established	25609	0	
3.3.3.3/32	connected	Established	25608	0	
5.5.5.5/32	connected	Established	25600	0	
40.40.40.0/24	10.10.10.2	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.10.10.0/24	connected	Established	impl-null	0	
2.2.2.2/32	10.10.10.2	Established	impl-null	0	

Session peer 3.3.3.3:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
40.40.40.0/24	connected	Established	25612	0	
30.30.30.0/24	connected	Established	25611	0	
4.4.4.4/32	20.20.20.2	Established	25609	0	
2.2.2.2/32	connected	Established	25608	0	
60.60.60.0/24	20.20.20.2	Established	25613	0	
5.5.5.5/32	20.20.20.2	Established	25610	0	
50.50.50.0/24	20.20.20.2	Established	impl-null	0	
20.20.20.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
3.3.3.3/32	20.20.20.2	Established	impl-null	0	

Session peer 4.4.4.4:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
50.50.50.0/24	connected	Established	25612	0	
40.40.40.0/24	connected	Established	25611	0	
5.5.5.5/32	connected	Established	25610	0	
3.3.3.3/32	connected	Established	25609	0	

2.2.2.2/32	connected	Established	25608	0
60.60.60.0/24	connected	Established	impl-null	0
30.30.30.0/24	connected	Established	impl-null	0
10.12.49.0/24	connected	Established	impl-null	0
4.4.4.4/32	connected	Established	impl-null	0

PE1#show ldp lsp

DOWNSTREAM LSP :

FEC	Nexthop Addr	State	Label	Req.ID	Attr
1.1.1.1/32	connected	Established	none	0	None
2.2.2.2/32	connected	Established	25608	0	
2.2.2.2/32	connected	Established	25608	0	
2.2.2.2/32	10.10.10.2	Established	impl-null	0	
3.3.3.3/32	connected	Established	25608	0	
3.3.3.3/32	connected	Established	25609	0	
3.3.3.3/32	20.20.20.2	Established	impl-null	0	
4.4.4.4/32	connected	Established	25609	0	
4.4.4.4/32	20.20.20.2	Established	25609	0	
4.4.4.4/32	connected	Established	impl-null	0	
5.5.5.5/32	connected	Established	25610	0	
5.5.5.5/32	20.20.20.2	Established	25610	0	
5.5.5.5/32	connected	Established	25600	0	
10.10.10.0/24	connected	Established	impl-null	0	
10.10.10.0/24	connected	Established	none	0	None
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	none	0	None
20.20.20.0/24	connected	Established	impl-null	0	
20.20.20.0/24	connected	Established	none	0	None
30.30.30.0/24	connected	Established	25610	0	
30.30.30.0/24	connected	Established	25611	0	
30.30.30.0/24	connected	Established	impl-null	0	
30.30.30.0/24	connected	Established	none	0	None
40.40.40.0/24	connected	Established	25611	0	
40.40.40.0/24	connected	Established	25612	0	
40.40.40.0/24	10.10.10.2	Established	impl-null	0	
50.50.50.0/24	connected	Established	25611	0	
50.50.50.0/24	connected	Established	25612	0	
50.50.50.0/24	20.20.20.2	Established	impl-null	0	
60.60.60.0/24	connected	Established	25612	0	
60.60.60.0/24	20.20.20.2	Established	25613	0	
60.60.60.0/24	connected	Established	impl-null	0	

UPSTREAM LSP :

FEC	State	Label	Req.ID	Attr
1.1.1.1/32	Established	impl-null	0	None
1.1.1.1/32	Established	impl-null	0	None
1.1.1.1/32	Established	impl-null	0	None

2.2.2.2/32	Established	25604	0	None
2.2.2.2/32	Established	25608	0	None
3.3.3.3/32	Established	25605	0	None
3.3.3.3/32	Established	25600	0	None
4.4.4.4/32	Established	25603	0	None
4.4.4.4/32	Established	25602	0	None
4.4.4.4/32	Established	25603	0	None
4.4.4.4/32	Established	25602	0	None
5.5.5.5/32	Established	25614	0	None
5.5.5.5/32	Established	25615	0	None
5.5.5.5/32	Established	25615	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
40.40.40.0/24	Established	25606	0	None
40.40.40.0/24	Established	25610	0	None
50.50.50.0/24	Established	25607	0	None
50.50.50.0/24	Established	25601	0	None
60.60.60.0/24	Established	25616	0	None
60.60.60.0/24	Established	25617	0	None
60.60.60.0/24	Established	25617	0	None

PE1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2					
L>	3.3.3.3/32	5	3	-	Yes	LSP_DEFAULT	3
xe2	No	20.20.20.2					
L>	4.4.4.4/32	3	7	-	Yes	LSP_DEFAULT	25609
xe2	No	20.20.20.2					
L>	5.5.5.5/32	7	5	-	Yes	LSP_DEFAULT	25610
xe2	No	20.20.20.2					
L>	40.40.40.0/24	2	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2					
L>	50.50.50.0/24	6	3	-	Yes	LSP_DEFAULT	3
xe2	No	20.20.20.2					

```

L> 60.60.60.0/24      4      6      -      Yes  LSP_DEFAULT  25613
xe2      No      20.20.20.2

```

```

PE1#show mpls forwarding-table 5.5.5.5/32

```

```

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

```

```

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

```

```

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

```

```

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	5.5.5.5/32	7	5	-	Yes	LSP_DEFAULT	25610
xe2	No	20.20.20.2					

```

PE1#show mpls ftn-table

```

```

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

```

```

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

```

```

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

```

```

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

```

```

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

```

```

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

```

```

Nexthop addr: 10.10.10.2      cross connect ix: 1, op code: Push

```

```

Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

```

```

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

```

```

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

```

```

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

```

```

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

```

```

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

```

```

Nexthop addr: 20.20.20.2      cross connect ix: 4, op code: Push

```

```

Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

```

```

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

```

```

Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4

```

```

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7

```

```

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

```

```

Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609

```

```

Nexthop addr: 20.20.20.2      cross connect ix: 2, op code: Push

```

```

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

```

```

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

```

```
Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
Nexthop addr: 20.20.20.2          cross connect ix: 5, op code: Push
```

Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613

Nexthop addr: 20.20.20.2 cross connect ix: 6, op code: Push

PE1#show mpls ftn-table 5.5.5.5/32

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610

NextHop addr: 20.20.20.2 cross connect ix: 5, op code: Push

PE1#show ldp fec prefix 5.5.5.5/32

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	NextHop Addr
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NL>	3.3.3.3	25610	No	20.20.20.2
	NL	2.2.2.2	25600	No	no nexthop

PE2:

PE2#show clns neighbors

Total number of L1 adjacencies: 3

Total number of L2 adjacencies: 0

Total number of adjacencies: 3

Tag 1: VRF : default

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
P3	xe3	5254.0015.057e	Up	25	L1	IS-IS
P2	xe2	5254.007b.6b14	Up	6	L1	IS-IS
P1	xe1	5254.00ea.0b3a	Up	6	L1	IS-IS

PE2#show clns neighbors detail

Total number of L1 adjacencies: 3

Total number of L2 adjacencies: 0

Total number of adjacencies: 3

Tag 1: VRF : default

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
P3	xe3	5254.0015.057e	Up	21	L1	IS-IS

 L1 Adjacency ID: 1

 L2 Adjacency ID: 2

 Uptime: 00:18:38

 Area Address(es): 49.0001

 IP Address(es): 60.60.60.1

 Level-1 Protocols Supported: IPv4

 Bidirectional Forwarding Detection is enabled

 Adjacency advertisement: Advertise

P2	xe2	5254.007b.6b14	Up	5	L1	IS-IS
----	-----	----------------	----	---	----	-------

 L1 Adjacency ID: 1

 L2 Adjacency ID: 2

 Uptime: 00:19:18

 Area Address(es): 49.0001

 IP Address(es): 50.50.50.1

 Level-1 Protocols Supported: IPv4

 Bidirectional Forwarding Detection is enabled

 Adjacency advertisement: Advertise

```

P1                xe1                5254.00ea.0b3a                Up                5                L1                IS-IS
L1  Adjacency ID: 1
L2  Adjacency ID: 2
Uptime: 00:19:48
Area Address(es): 49.0001
IP Address(es): 40.40.40.1
Level-1 Protocols Supported: IPv4
Bidirectional Forwarding Detection is enabled
Adjacency advertisement: Advertise

```

PE2#show isis database

Tag 1: VRF : default

IS-IS Level-1 Link State Database:

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
PE1.00-00	0x0000000B	0xD9A0	881	0/0/0
PE1.02-00	0x00000002	0x8644	821	0/0/0
P1.00-00	0x00000009	0xC058	949	0/0/0
P1.03-00	0x00000002	0xBC08	909	0/0/0
P2.00-00	0x00000008	0x0153	953	0/0/0
P2.02-00	0x00000002	0x7453	845	0/0/0
P2.03-00	0x00000002	0xBD05	939	0/0/0
P3.00-00	0x00000008	0xDFAF	974	0/0/0
P3.02-00	0x00000002	0x7550	860	0/0/0
PE2.00-00	* 0x0000000B	0xE1FF	971	0/0/0
PE2.04-00	* 0x00000002	0xA41A	970	0/0/0

PE2#show isis database verbose

Tag 1: VRF : default

IS-IS Level-1 Link State Database:

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
PE1.00-00	0x0000000B	0xD9A0	871	0/0/0

Area Address: 49.0001
 NLPID: 0xCC
 Hostname: PE1
 IP Address: 1.1.1.1
 Router ID: 10.12.49.172
 Metric: 20 IS-Extended PE1.02
 IPv4 Interface Address: 10.10.10.1
 Neighbor IP Address: 10.10.10.1
 Maximum Link Bandwidth : 100000.00 kbits/sec
 Reservable Bandwidth : 100000.00 kbits/sec
 Unreserved Bandwidth:
 Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
 Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
 Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
 Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
 Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
 Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
 Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
 Unreserved Bandwidth at priority 7: 100000.00 kbits/sec

```

TE-Default Metric: 20
Metric: 15          IS-Extended P2.02
IPv4 Interface Address: 20.20.20.1
Neighbor IP Address: 20.20.20.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 15
Metric: 60          IS-Extended P3.02
IPv4 Interface Address: 30.30.30.1
Neighbor IP Address: 30.30.30.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 60
Metric: 10          IP-Extended 1.1.1.1/32
Metric: 20          IP-Extended 10.10.10.0/24
Metric: 15          IP-Extended 20.20.20.0/24
Metric: 60          IP-Extended 30.30.30.0/24
PE1.02-00          0x00000002  0x8644          811          0/0/0
Metric: 0          IS-Extended PE1.00
Metric: 0          IS-Extended P1.00
P1.00-00          0x00000009  0xC058          940          0/0/0
Area Address: 49.0001
NLPID: 0xCC
Hostname: P1
IP Address: 2.2.2.2
Router ID: 10.12.49.173
Metric: 10          IS-Extended PE1.02
IPv4 Interface Address: 10.10.10.2
Neighbor IP Address: 10.10.10.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:

```

```
Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IS-Extended P1.03
IPv4 Interface Address: 40.40.40.1
Neighbor IP Address: 40.40.40.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IP-Extended 2.2.2.2/32
Metric: 10          IP-Extended 10.10.10.0/24
Metric: 10          IP-Extended 40.40.40.0/24
P1.03-00            0x00000002  0xBC08          899          0/0/0
Metric: 0           IS-Extended P1.00
Metric: 0           IS-Extended PE2.00
P2.00-00            0x00000008  0x0153          943          0/0/0
Area Address: 49.0001
NLPID: 0xCC
Hostname: P2
IP Address: 3.3.3.3
Router ID: 10.12.49.176
Metric: 10          IS-Extended P2.02
IPv4 Interface Address: 20.20.20.2
Neighbor IP Address: 20.20.20.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
```

```
TE-Default Metric: 10
Metric: 10          IS-Extended P2.03
IPv4 Interface Address: 50.50.50.1
Neighbor IP Address: 50.50.50.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IP-Extended 3.3.3.3/32
Metric: 10          IP-Extended 50.50.50.0/24
Metric: 10          IP-Extended 20.20.20.0/24
P2.02-00            0x00000002    0x7453          835          0/0/0
Metric: 0           IS-Extended P2.00
Metric: 0           IS-Extended PE1.00
P2.03-00            0x00000002    0xBD05          929          0/0/0
Metric: 0           IS-Extended P2.00
Metric: 0           IS-Extended PE2.00
P3.00-00            0x00000008    0xDFAF          964          0/0/0
Area Address: 49.0001
NLPID:              0xCC
Hostname:           P3
IP Address:         4.4.4.4
Router ID:          10.12.49.177
Metric: 10          IS-Extended P3.02
IPv4 Interface Address: 30.30.30.2
Neighbor IP Address: 30.30.30.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IS-Extended PE2.04
IPv4 Interface Address: 60.60.60.1
Neighbor IP Address: 60.60.60.2
Maximum Link Bandwidth : 100000.00 kbits/sec
```

```
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10      IP-Extended 4.4.4.4/32
Metric: 10      IP-Extended 60.60.60.0/24
Metric: 10      IP-Extended 30.30.30.0/24
P3.02-00      0x00000002  0x7550      850      0/0/0
Metric: 0      IS-Extended P3.00
Metric: 0      IS-Extended PE1.00
PE2.00-00      * 0x0000000B  0xE1FF      961      0/0/0
Area Address: 49.0001
NLPID: 0xCC
Hostname: PE2
IP Address: 5.5.5.5
Router ID: 10.12.49.174
Metric: 10      IS-Extended P1.03
IPv4 Interface Address: 40.40.40.2
Neighbor IP Address: 40.40.40.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10      IS-Extended P2.03
IPv4 Interface Address: 50.50.50.2
Neighbor IP Address: 50.50.50.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
```

```

    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IS-Extended PE2.04
IPv4 Interface Address: 60.60.60.2
Neighbor IP Address: 60.60.60.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IP-Extended 5.5.5.5/32
Metric: 10          IP-Extended 60.60.60.0/24
Metric: 10          IP-Extended 50.50.50.0/24
Metric: 10          IP-Extended 40.40.40.0/24
PE2.04-00          * 0x00000002  0xA41A          960          0/0/0
Metric: 0          IS-Extended PE2.00
Metric: 0          IS-Extended P3.00

PE2#show ldp session
Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
1.1.1.1              xe2        Active     OPERATIONAL 30         00:19:22
2.2.2.2              xe1        Active     OPERATIONAL 30         00:19:27
3.3.3.3              xe2        Active     OPERATIONAL 30         00:19:24
4.4.4.4              xe3        Active     OPERATIONAL 30         00:19:12

PE2#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*          0.0.0.0/0 [0/0] via 10.12.49.1, xe0
i L1        1.1.1.1/32 [115/30] via 60.60.60.1, xe1, 00:20:03
              [115/30] via 50.50.50.1, xe2

```

```

[115/30] via 40.40.40.1, xe1
i L1      2.2.2.2/32 [115/20] via 40.40.40.1, xe1, 00:19:01
i L1      3.3.3.3/32 [115/20] via 50.50.50.1, xe2, 00:19:01
i L1      4.4.4.4/32 [115/20] via 60.60.60.1, xe1, 00:19:01
C         5.5.5.5/32 is directly connected, lo, 00:26:47
i L1      10.10.10.0/24 [115/20] via 40.40.40.1, xe1, 00:19:01
C         10.12.49.0/24 is directly connected, xe0, 00:38:00
i L1      20.20.20.0/24 [115/20] via 50.50.50.1, xe2, 00:19:01
i L1      30.30.30.0/24 [115/20] via 60.60.60.1, xe1, 00:19:01
C         40.40.40.0/24 is directly connected, xe1, 00:26:47
C         50.50.50.0/24 is directly connected, xe2, 00:26:47
C         60.60.60.0/24 is directly connected, xe1, 00:26:47
C         127.0.0.0/8 is directly connected, lo, 03:05:08

```

PE2#show ip route summary

```

-----
IP routing table name is Default-IP-Routing-Table(0)
-----

```

```

IP routing table maximum-paths    : 8
Total number of IPv4 routes       : 14
Total number of IPv4 paths        : 16
Pending routes (due to route max reached): 0
Route Source    Networks
kernel          1
connected       6
isis            7
Total           14
FIB             14

```

ECMP statistics (active in ASIC):

```

Total number of IPv4 ECMP routes : 1
Total number of IPv4 ECMP paths  : 3
Number of routes with 3 ECMP paths: 1

```

PE2#show ip interface brief

'*' - address is assigned by dhcp client

Interface	IP-Address	Admin-Status	Link-Status
xe0	*10.12.49.174	up	up
xe3	60.60.60.2	up	up
xe2	unassigned	up	up
xe2	50.50.50.2	up	up
xe4	unassigned	up	up
xe5	unassigned	up	up
xe6	unassigned	up	up
xe7	unassigned	up	up
xe1	40.40.40.2	up	up

xe9	unassigned	up	up
xe10	unassigned	up	up
xe11	unassigned	up	up
xe12	unassigned	up	up
xe13	unassigned	up	up
lo	127.0.0.1	up	up

PE2#show ip isis route fast-reroute

Tag : 1 VRF : default

Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
 D - discard, LP - Link Protecting, NP - Node Protecting,
 BP - Broadcast Interface Disjoint, Pri - Primary Path,
 Sec - Secondary Path, DP - Downstream Path

PE2#show ldp routes

Prefix Addr	Nexthop Addr	Intf	Owner
0.0.0.0/0	10.12.49.1	xe0	kernel
1.1.1.1/32	40.40.40.1	xe1	isis
	60.60.60.1	xe3	isis
	50.50.50.1	xe2	isis
2.2.2.2/32	40.40.40.1	xe1	isis
3.3.3.3/32	50.50.50.1	xe2	isis
4.4.4.4/32	60.60.60.1	xe3	isis
5.5.5.5/32	0.0.0.0	lo	connected
10.10.10.0/24	40.40.40.1	xe1	isis
10.12.49.0/24	0.0.0.0	xe0	connected
20.20.20.0/24	50.50.50.1	xe2	isis
30.30.30.0/24	60.60.60.1	xe3	isis
40.40.40.0/24	0.0.0.0	xe1	connected
50.50.50.0/24	0.0.0.0	xe2	connected
60.60.60.0/24	0.0.0.0	xe3	connected

PE2#show ldp fec

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	NL>	4.4.4.4	25600	No	60.60.60.1
	NL>	3.3.3.3	25600	No	50.50.50.1
	NL>	2.2.2.2	25601	No	40.40.40.1
2.2.2.2/32	NL>	2.2.2.2	impl-null	No	40.40.40.1
3.3.3.3/32	NL>	3.3.3.3	impl-null	No	50.50.50.1
4.4.4.4/32	NL>	4.4.4.4	impl-null	No	60.60.60.1
5.5.5.5/32	E >	non-existent	none	No	connected
10.10.10.0/24	NL>	2.2.2.2	impl-null	No	40.40.40.1
10.12.49.0/24	NL	4.4.4.4	impl-null	No	connected
	NL	3.3.3.3	impl-null	No	connected
	NL	2.2.2.2	impl-null	No	connected

	E >	non-existent	none	No	connected
20.20.20.0/24	NL	4.4.4.4	25605	No	no nexthop
	NL>	3.3.3.3	impl-null	No	50.50.50.1
	NL	2.2.2.2	25604	No	no nexthop
30.30.30.0/24	NL>	4.4.4.4	impl-null	No	60.60.60.1
40.40.40.0/24	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
50.50.50.0/24	NL	3.3.3.3	impl-null	No	connected
	E >	non-existent	none	No	connected
60.60.60.0/24	NL	4.4.4.4	impl-null	No	connected
	E >	non-existent	none	No	connected

PE2#show ldp downstream

Session peer 1.1.1.1:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
-----	--------------	-------	-------	--------	------

Session peer 2.2.2.2:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
40.40.40.0/24	connected	Established	impl-null	0	
20.20.20.0/24	connected	Established	25604	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.10.10.0/24	40.40.40.1	Established	impl-null	0	
2.2.2.2/32	40.40.40.1	Established	impl-null	0	
1.1.1.1/32	40.40.40.1	Established	25601	0	

Session peer 3.3.3.3:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
50.50.50.0/24	connected	Established	impl-null	0	
20.20.20.0/24	50.50.50.1	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
3.3.3.3/32	50.50.50.1	Established	impl-null	0	
1.1.1.1/32	50.50.50.1	Established	25600	0	

Session peer 4.4.4.4:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
60.60.60.0/24	connected	Established	impl-null	0	
30.30.30.0/24	60.60.60.1	Established	impl-null	0	
20.20.20.0/24	connected	Established	25605	0	
10.12.49.0/24	connected	Established	impl-null	0	
4.4.4.4/32	60.60.60.1	Established	impl-null	0	
1.1.1.1/32	60.60.60.1	Established	25600	0	

PE2#show ldp lsp

DOWNSTREAM LSP :

FEC	Nexthop Addr	State	Label	Req.ID	Attr
1.1.1.1/32	60.60.60.1	Established	25600	0	
1.1.1.1/32	50.50.50.1	Established	25600	0	
1.1.1.1/32	40.40.40.1	Established	25601	0	
2.2.2.2/32	40.40.40.1	Established	impl-null	0	
3.3.3.3/32	50.50.50.1	Established	impl-null	0	
4.4.4.4/32	60.60.60.1	Established	impl-null	0	
5.5.5.5/32	connected	Established	none	0	None
10.10.10.0/24	40.40.40.1	Established	impl-null	0	

10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	none	0	None
20.20.20.0/24	connected	Established	25605	0	
20.20.20.0/24	50.50.50.1	Established	impl-null	0	
20.20.20.0/24	connected	Established	25604	0	
30.30.30.0/24	60.60.60.1	Established	impl-null	0	
40.40.40.0/24	connected	Established	impl-null	0	
40.40.40.0/24	connected	Established	none	0	None
50.50.50.0/24	connected	Established	impl-null	0	
50.50.50.0/24	connected	Established	none	0	None
60.60.60.0/24	connected	Established	impl-null	0	
60.60.60.0/24	connected	Established	none	0	None

UPSTREAM LSP :

FEC	State	Label	Req.ID	Attr
2.2.2.2/32	Established	25601	0	None
2.2.2.2/32	Established	25608	0	None
3.3.3.3/32	Established	25614	0	None
3.3.3.3/32	Established	25609	0	None
4.4.4.4/32	Established	25615	0	None
4.4.4.4/32	Established	25603	0	None
5.5.5.5/32	Established	impl-null	0	None
5.5.5.5/32	Established	impl-null	0	None
5.5.5.5/32	Established	impl-null	0	None
10.10.10.0/24	Established	25604	0	None
10.10.10.0/24	Established	25611	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	25616	0	None
20.20.20.0/24	Established	25616	0	None
20.20.20.0/24	Established	25612	0	None
20.20.20.0/24	Established	25612	0	None
30.30.30.0/24	Established	25617	0	None
30.30.30.0/24	Established	25606	0	None
40.40.40.0/24	Established	impl-null	0	None
40.40.40.0/24	Established	impl-null	0	None
40.40.40.0/24	Established	impl-null	0	None
50.50.50.0/24	Established	impl-null	0	None
50.50.50.0/24	Established	impl-null	0	None
50.50.50.0/24	Established	impl-null	0	None
60.60.60.0/24	Established	impl-null	0	None
60.60.60.0/24	Established	impl-null	0	None
60.60.60.0/24	Established	impl-null	0	None

PE2#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	1.1.1.1/32	1	1	-	Yes	LSP_DEFAULT	25601
xe1	No	40.40.40.1					
			7	-	Yes	LSP_DEFAULT	25600
xe3	No	60.60.60.1					
			8	-	Yes	LSP_DEFAULT	25600
xe2	No	50.50.50.1					
L>	2.2.2.2/32	2	2	-	Yes	LSP_DEFAULT	3
xe1	No	40.40.40.1					
L>	3.3.3.3/32	3	9	-	Yes	LSP_DEFAULT	3
xe2	No	50.50.50.1					
L>	4.4.4.4/32	4	10	-	Yes	LSP_DEFAULT	3
xe3	No	60.60.60.1					
L>	10.10.10.0/24	5	2	-	Yes	LSP_DEFAULT	3
xe1	No	40.40.40.1					
L>	20.20.20.0/24	6	9	-	Yes	LSP_DEFAULT	3
xe2	No	50.50.50.1					
L>	30.30.30.0/24	7	10	-	Yes	LSP_DEFAULT	3
xe3	No	60.60.60.1					

PE2#show mpls forwarding-table 5.5.5.5/32

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					

PE2#show mpls forwarding-table 1.1.1.1/32

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	1.1.1.1/32	1	1	-	Yes	LSP_DEFAULT	25601
xe1	No	40.40.40.1					
			7	-	Yes	LSP_DEFAULT	25600
xe3	No	60.60.60.1					
			8	-	Yes	LSP_DEFAULT	25600
xe2	No	50.50.50.1					

PE2#show mpls ftn-table

Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
 none
 Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
 Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: LDP, Stale: NO, out intf: xe1, out label: 25601
Nexthop addr: 40.40.40.1 cross connect ix: 1, op code: Push

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
Nexthop addr: 60.60.60.1 cross connect ix: 1, op code: Push

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe2, out label: 25600
Nexthop addr: 50.50.50.1 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 2.2.2.2/32, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 40.40.40.1 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 50.50.50.1 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 10
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 60.60.60.1 cross connect ix: 8, op code: Push

Primary FTN entry with FEC: 10.10.10.0/24, id: 5, row status: Active, Tunnel-Policy: N/A

```
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 40.40.40.1          cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 20.20.20.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 50.50.50.1          cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 30.30.30.0/24, id: 7, row status: Active, Tunnel-Policy: N/
A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 10
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 60.60.60.1          cross connect ix: 8, op code: Push

PE2#show mpls ftn-table 1.1.1.1/32
Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: LDP, Stale: NO, out intf: xe1, out label: 25601
Nexthop addr: 40.40.40.1          cross connect ix: 1, op code: Push

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
Nexthop addr: 60.60.60.1          cross connect ix: 1, op code: Push

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
```

Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe2, out label: 25600
 Nexthop addr: 50.50.50.1 cross connect ix: 1, op code: Push

PE2#show ldp fec prefix 1.1.1.1/32

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	NL>	4.4.4.4	25600	No	60.60.60.1
	NL>	3.3.3.3	25600	No	50.50.50.1
	NL>	2.2.2.2	25601	No	40.40.40.1

RTR1 - FRR Configuration

Now that NSM, ISIS and LDP are all configured, FRR for IGP and LDP can be enabled using below configurations.

#configure terminal	Enter configuration mode.
(config)#router isis 1	Create an IS-IS routing instance for area 49 with instance 1
(config-router)#fast-reroute per-prefix level-1 proto ipv4 all	Configure LFA-FRR to calculate the available backup path for all L1 ipv4 prefixes learnt
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#fast-reroute	Configure LDP LFA-FRR to calculate the available backup path
(config-router)#exit	Exit router mode.
(config)#commit	Commit all the configurations

Validation

PE1#show clns neighbors

Total number of L1 adjacencies: 3
 Total number of L2 adjacencies: 0
 Total number of adjacencies: 3
 Tag 1: VRF : default

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
P1	xe1	5254.0002.5b0a	Up	28	L1	IS-IS
P2	xe2	5254.009b.f9a2	Up	7	L1	IS-IS
P3	xe3	5254.005d.e995	Up	5	L1	IS-IS

PE1#show clns neighbors detail

Total number of L1 adjacencies: 3
 Total number of L2 adjacencies: 0
 Total number of adjacencies: 3
 Tag 1: VRF : default

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
-----------	-----------	------	-------	----------	------	----------

```

P1          xe1          5254.0002.5b0a      Up      22          L1      IS-IS
  L1 Adjacency ID: 1
  L2 Adjacency ID: 2
  Uptime: 00:50:07
  Area Address(es): 49.0001
  IP Address(es): 10.10.10.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
P2          xe2          5254.009b.f9a2      Up       7          L1      IS-IS
  L1 Adjacency ID: 1
  L2 Adjacency ID: 2
  Uptime: 00:49:43
  Area Address(es): 49.0001
  IP Address(es): 20.20.20.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
P3          xe3          5254.005d.e995      Up       5          L1      IS-IS
  L1 Adjacency ID: 1
  L2 Adjacency ID: 2
  Uptime: 00:49:18
  Area Address(es): 49.0001
  IP Address(es): 30.30.30.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise

```

PE1#show isis database

Tag 1: VRF : default

IS-IS Level-1 Link State Database:

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
PE1.00-00	* 0x0000000D	0xD5A2	956	0/0/0
PE1.02-00	* 0x00000004	0x8246	895	0/0/0
P1.00-00	0x0000000B	0xBC5A	1023	0/0/0
P1.03-00	0x00000004	0xB80A	982	0/0/0
P2.00-00	0x0000000A	0xFC55	1027	0/0/0
P2.02-00	0x00000004	0x7055	918	0/0/0
P2.03-00	0x00000004	0xB907	1012	0/0/0
P3.00-00	0x0000000A	0xDBB1	1047	0/0/0
P3.02-00	0x00000004	0x7152	933	0/0/0
PE2.00-00	0x0000000D	0xDD02	1043	0/0/0
PE2.04-00	0x00000004	0xA01C	1042	0/0/0

PE1#show isis database verbose

Tag 1: VRF : default

IS-IS Level-1 Link State Database:

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
PE1.00-00	* 0x0000000D	0xD5A2	947	0/0/0

```
Area Address: 49.0001
NLPID:      0xCC
Hostname:    PE1
IP Address:  1.1.1.1
Router ID:   10.12.49.172
Metric:      20          IS-Extended PE1.02
  IPv4 Interface Address: 10.10.10.1
  Neighbor IP Address: 10.10.10.1
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 20
Metric:      15          IS-Extended P2.02
  IPv4 Interface Address: 20.20.20.1
  Neighbor IP Address: 20.20.20.2
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 15
Metric:      60          IS-Extended P3.02
  IPv4 Interface Address: 30.30.30.1
  Neighbor IP Address: 30.30.30.2
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 60
```

```

Metric: 10          IP-Extended 1.1.1.1/32
Metric: 20          IP-Extended 10.10.10.0/24
Metric: 15          IP-Extended 20.20.20.0/24
Metric: 60          IP-Extended 30.30.30.0/24
PE1.02-00          * 0x00000004  0x8246          887          0/0/0
Metric: 0           IS-Extended PE1.00
Metric: 0           IS-Extended P1.00
P1.00-00           0x0000000B  0xBC5A          1015         0/0/0
Area Address: 49.0001
NLPID: 0xCC
Hostname: P1
IP Address: 2.2.2.2
Router ID: 10.12.49.173
Metric: 10          IS-Extended PE1.02
IPv4 Interface Address: 10.10.10.2
Neighbor IP Address: 10.10.10.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IS-Extended P1.03
IPv4 Interface Address: 40.40.40.1
Neighbor IP Address: 40.40.40.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IP-Extended 2.2.2.2/32
Metric: 10          IP-Extended 10.10.10.0/24
Metric: 10          IP-Extended 40.40.40.0/24
P1.03-00           0x00000004  0xB80A          974          0/0/0
Metric: 0           IS-Extended P1.00
Metric: 0           IS-Extended PE2.00
P2.00-00           0x0000000A  0xFC55          1018         0/0/0

```

```

Area Address: 49.0001
NLPID:       0xCC
Hostname:    P2
IP Address:  3.3.3.3
Router ID:   10.12.49.176
Metric:      10          IS-Extended P2.02
  IPv4 Interface Address: 20.20.20.2
  Neighbor IP Address: 20.20.20.2
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 10
Metric:      10          IS-Extended P2.03
  IPv4 Interface Address: 50.50.50.1
  Neighbor IP Address: 50.50.50.1
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 10
Metric:      10          IP-Extended 3.3.3.3/32
Metric:      10          IP-Extended 50.50.50.0/24
Metric:      10          IP-Extended 20.20.20.0/24
P2.02-00      0x00000004  0x7055          910          0/0/0
  Metric:      0          IS-Extended P2.00
  Metric:      0          IS-Extended PE1.00
P2.03-00      0x00000004  0xB907          1004         0/0/0
  Metric:      0          IS-Extended P2.00
  Metric:      0          IS-Extended PE2.00
P3.00-00      0x0000000A  0xDBB1          1039         0/0/0
Area Address: 49.0001
NLPID:       0xCC
Hostname:    P3
IP Address:  4.4.4.4
Router ID:   10.12.49.177

```

```
Metric: 10          IS-Extended P3.02
  IPv4 Interface Address: 30.30.30.2
  Neighbor IP Address: 30.30.30.2
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 10
Metric: 10          IS-Extended PE2.04
  IPv4 Interface Address: 60.60.60.1
  Neighbor IP Address: 60.60.60.2
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 10
Metric: 10          IP-Extended 4.4.4.4/32
Metric: 10          IP-Extended 60.60.60.0/24
Metric: 10          IP-Extended 30.30.30.0/24
P3.02-00            0x00000004    0x7152          925          0/0/0
  Metric: 0          IS-Extended P3.00
  Metric: 0          IS-Extended PE1.00
PE2.00-00            0x0000000D    0xDD02          1035         0/0/0
Area Address: 49.0001
NLPID:             0xCC
Hostname:          PE2
IP Address:        5.5.5.5
Router ID:         10.12.49.174
Metric: 10          IS-Extended P1.03
  IPv4 Interface Address: 40.40.40.2
  Neighbor IP Address: 40.40.40.1
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
```

```
Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IS-Extended P2.03
IPv4 Interface Address: 50.50.50.2
Neighbor IP Address: 50.50.50.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IS-Extended PE2.04
IPv4 Interface Address: 60.60.60.2
Neighbor IP Address: 60.60.60.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IP-Extended 5.5.5.5/32
Metric: 10          IP-Extended 60.60.60.0/24
Metric: 10          IP-Extended 50.50.50.0/24
Metric: 10          IP-Extended 40.40.40.0/24
PE2.04-00           0x00000004  0xA01C          1034          0/0/0
Metric: 0           IS-Extended PE2.00
Metric: 0           IS-Extended P3.00

PE1#show ldp session
Peer IP Address      IF Name    My Role    State        KeepAlive  UpTime
5.5.5.5              xe3        Passive    OPERATIONAL  30         00:48:09
2.2.2.2              xe1        Passive    OPERATIONAL  30         00:50:11
```

```

3.3.3.3          xe2      Passive  OPERATIONAL  30    00:49:23
4.4.4.4          xe3      Passive  OPERATIONAL  30    00:49:30

```

```
PE1#show ip route
```

```
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
```

```
O - OSPF, IA - OSPF inter area
```

```
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
```

```
E1 - OSPF external type 1, E2 - OSPF external type 2
```

```
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
```

```
ia - IS-IS inter area, E - EVPN,
```

```
v - vrf leaked
```

```
* - candidate default
```

```
IP Route Table for VRF "default"
```

```
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
```

```

K*          0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C           1.1.1.1/32 is directly connected, lo, 00:58:19
i L1        2.2.2.2/32 [115/30] via 10.10.10.2, xe1, 00:50:20
i L1        3.3.3.3/32 [115/25] via 20.20.20.2, xe2, 00:48:50
i L1        4.4.4.4/32 [115/45] via 20.20.20.2, xe2, 00:47:10
i L1        5.5.5.5/32 [115/35] via 20.20.20.2, xe2, 00:48:00
C           10.10.10.0/24 is directly connected, xe1, 00:58:19
C           10.12.49.0/24 is directly connected, xe0, 01:02:58
C           20.20.20.0/24 is directly connected, xe2, 00:58:19
C           30.30.30.0/24 is directly connected, xe3, 00:58:19
i L1        40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 00:48:00
i L1        50.50.50.0/24 [115/25] via 20.20.20.2, xe2, 00:48:00
i L1        60.60.60.0/24 [115/35] via 20.20.20.2, xe2, 00:48:00
C           127.0.0.0/8 is directly connected, lo, 03:34:09

```

```
PE1#show ip route summary
```

```
-----
IP routing table name is Default-IP-Routing-Table(0)
-----
```

```

IP routing table maximum-paths      : 8
Total number of IPv4 routes         : 14
Total number of IPv4 paths          : 14
Pending routes (due to route max reached): 0
Route Source      Networks
kernel            1
connected         6
isis              7
Total             14
FIB               14

```

```
ECMP statistics (active in ASIC):
```

```
Total number of IPv4 ECMP routes : 0
```

```
Total number of IPv4 ECMP paths  : 0
```

LFA Non ECMP statistics

Total number of Routes : 7
Total number of Primary Paths : 7
Total number of Backup Paths : 7

PE1#show ip interface brief

'*' - address is assigned by dhcp client

Interface	IP-Address	Admin-Status	Link-Status
xe0	*10.12.49.172	up	up
xe1	unassigned	up	up
xe1	10.10.10.1	up	up
xe3	unassigned	up	up
xe4	unassigned	up	up
xe5	unassigned	up	up
xe6	unassigned	up	up
xe7	unassigned	up	up
xe8	unassigned	up	up
xe9	unassigned	up	up
xe10	unassigned	up	up
xe11	unassigned	up	up
xe2	20.20.20.1	up	up
xe3	30.30.30.1	up	up
lo	127.0.0.1	up	up

PE1#show ip isis route fast-reroute

Tag : 1 VRF : default

Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
D - discard, LP - Link Protecting, NP - Node Protecting,
BP - Broadcast Interface Disjoint, Pri - Primary Path,
Sec - Secondary Path, DP - Downstream Path

L1 2.2.2.2/32

Primary Path via : 10.10.10.2, xe1
FRR Backup Path via : 20.20.20.2, xe2
FRR Metric : 45
Protection Provided : LP BP

L1 3.3.3.3/32

Primary Path via : 20.20.20.2, xe2
FRR Backup Path via : 10.10.10.2, xe1
FRR Metric : 50
Protection Provided : LP BP

L1 4.4.4.4/32

Primary Path via : 20.20.20.2, xe2

```

FRR Backup Path via : 10.10.10.2, xe1
FRR Metric           : 50
Protection Provided  : LP NP BP DP

```

```

L1 5.5.5.5/32
Primary Path via      : 20.20.20.2, xe2
FRR Backup Path via   : 10.10.10.2, xe1
FRR Metric            : 40
Protection Provided   : LP NP BP DP

```

```

L1 40.40.40.0/24
Primary Path via      : 10.10.10.2, xe1
FRR Backup Path via   : 20.20.20.2, xe2
FRR Metric            : 35
Protection Provided   : LP NP BP DP

```

```

L1 50.50.50.0/24
Primary Path via      : 20.20.20.2, xe2
FRR Backup Path via   : 10.10.10.2, xe1
FRR Metric            : 40
Protection Provided   : LP NP BP DP

```

```

L1 60.60.60.0/24
Primary Path via      : 20.20.20.2, xe2
FRR Backup Path via   : 10.10.10.2, xe1
FRR Metric            : 40
Protection Provided   : LP NP BP DP

```

```
PE1#show ldp routes
```

Prefix Addr	Nexthop Addr	Intf	Backup Addr	Backup Intf	Owner
0.0.0.0/0	10.12.49.1	xe0	-	-	kernel
1.1.1.1/32	0.0.0.0	lo	-	-	connected
2.2.2.2/32	10.10.10.2	xe1	20.20.20.2	xe2	isis
3.3.3.3/32	20.20.20.2	xe2	10.10.10.2	xe1	isis
4.4.4.4/32	20.20.20.2	xe2	10.10.10.2	xe1	isis
5.5.5.5/32	20.20.20.2	xe2	10.10.10.2	xe1	isis
10.10.10.0/24	0.0.0.0	xe1	-	-	connected
10.12.49.0/24	0.0.0.0	xe0	-	-	connected
20.20.20.0/24	0.0.0.0	xe2	-	-	connected
30.30.30.0/24	0.0.0.0	xe3	-	-	connected
40.40.40.0/24	10.10.10.2	xe1	20.20.20.2	xe2	isis
50.50.50.0/24	20.20.20.2	xe2	10.10.10.2	xe1	isis
60.60.60.0/24	20.20.20.2	xe2	10.10.10.2	xe1	isis

```
PE1#show ldp fec
```

```

LSR codes      : E/N - LSR is egress/non-egress for this FEC,
                  L - LSR received a label for this FEC,
                  P - Primary route, B - LFA Backup route,
                  R - Remote LFA Backup route,

```

> - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	E >	non-existent	none	No	connected
2.2.2.2/32	NL	4.4.4.4	25608	No	no nexthop
	NLB>	3.3.3.3	25608	No	20.20.20.2
	NLP>	2.2.2.2	impl-null	No	10.10.10.2
3.3.3.3/32	NLB>	2.2.2.2	25608	No	10.10.10.2
	NL	4.4.4.4	25609	No	no nexthop
	NLP>	3.3.3.3	impl-null	No	20.20.20.2
4.4.4.4/32	NLB>	2.2.2.2	25609	No	10.10.10.2
	NLP>	3.3.3.3	25609	No	20.20.20.2
	NL	4.4.4.4	impl-null	No	no nexthop
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NLP>	3.3.3.3	25610	No	20.20.20.2
	NLB>	2.2.2.2	25600	No	10.10.10.2
10.10.10.0/24	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
10.12.49.0/24	NL	3.3.3.3	impl-null	No	connected
	NL	4.4.4.4	impl-null	No	connected
	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
20.20.20.0/24	NL	3.3.3.3	impl-null	No	connected
	E >	non-existent	none	No	connected
30.30.30.0/24	NL	2.2.2.2	25610	No	connected
	NL	3.3.3.3	25611	No	connected
	NL	4.4.4.4	impl-null	No	connected
	E >	non-existent	none	No	connected
40.40.40.0/24	NL	4.4.4.4	25611	No	no nexthop
	NLB>	3.3.3.3	25612	No	20.20.20.2
	NLP>	2.2.2.2	impl-null	No	10.10.10.2
50.50.50.0/24	NLB>	2.2.2.2	25611	No	10.10.10.2
	NL	4.4.4.4	25612	No	no nexthop
	NLP>	3.3.3.3	impl-null	No	20.20.20.2
60.60.60.0/24	NLB>	2.2.2.2	25612	No	10.10.10.2
	NLP>	3.3.3.3	25613	No	20.20.20.2
	NL	4.4.4.4	impl-null	No	no nexthop

PE1#show ldp downstream

Codes: P - Primary route, B - Backup route

Session peer 5.5.5.5:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
Code					

Codes: P - Primary route, B - Backup route

Session peer 2.2.2.2:

FEC	Nexthop Addr	State	Label	Req.ID	Attr
Code					

60.60.60.0/24	connected	Established	25612	0	
---------------	-----------	-------------	-------	---	--

60.60.60.0/24	10.10.10.2	Established	25612	0	
---------------	------------	-------------	-------	---	--

B	50.50.50.0/24	connected	Established	25611	0
---	---------------	-----------	-------------	-------	---

50.50.50.0/24	10.10.10.2	Established	25611	0	
---------------	------------	-------------	-------	---	--

B					
---	--	--	--	--	--

	30.30.30.0/24	connected	Established	25610	0
	4.4.4.4/32	connected	Established	25609	0
	4.4.4.4/32	10.10.10.2	Established	25609	0
B	3.3.3.3/32	connected	Established	25608	0
	3.3.3.3/32	10.10.10.2	Established	25608	0
B	5.5.5.5/32	connected	Established	25600	0
	5.5.5.5/32	10.10.10.2	Established	25600	0
B	40.40.40.0/24	10.10.10.2	Established	impl-null	0
P	10.12.49.0/24	connected	Established	impl-null	0
	10.10.10.0/24	connected	Established	impl-null	0
	2.2.2.2/32	10.10.10.2	Established	impl-null	0
P					

Codes: P - Primary route, B - Backup route

Session peer 3.3.3.3:

	FEC	NextHop Addr	State	Label	Req.ID	Attr
	Code					
	40.40.40.0/24	connected	Established	25612	0	
	40.40.40.0/24	20.20.20.2	Established	25612	0	
B	30.30.30.0/24	connected	Established	25611	0	
	4.4.4.4/32	20.20.20.2	Established	25609	0	
P	2.2.2.2/32	connected	Established	25608	0	
	2.2.2.2/32	20.20.20.2	Established	25608	0	
B	60.60.60.0/24	20.20.20.2	Established	25613	0	
P	5.5.5.5/32	20.20.20.2	Established	25610	0	
P	50.50.50.0/24	20.20.20.2	Established	impl-null	0	
P	20.20.20.0/24	connected	Established	impl-null	0	
	10.12.49.0/24	connected	Established	impl-null	0	
	3.3.3.3/32	20.20.20.2	Established	impl-null	0	
P						

Codes: P - Primary route, B - Backup route

Session peer 4.4.4.4:

	FEC	NextHop Addr	State	Label	Req.ID	Attr
	Code					
	50.50.50.0/24	connected	Established	25612	0	
	40.40.40.0/24	connected	Established	25611	0	
	5.5.5.5/32	connected	Established	25610	0	
	3.3.3.3/32	connected	Established	25609	0	
	2.2.2.2/32	connected	Established	25608	0	
	60.60.60.0/24	connected	Established	impl-null	0	
	30.30.30.0/24	connected	Established	impl-null	0	
	10.12.49.0/24	connected	Established	impl-null	0	
	4.4.4.4/32	connected	Established	impl-null	0	

```
PE1#show ldp lsp
```

```
DOWNSTREAM LSP :
```

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
1.1.1.1/32	connected	Established	none	0	None
2.2.2.2/32	connected	Established	25608	0	
2.2.2.2/32	connected	Established	25608	0	
2.2.2.2/32	20.20.20.2	Established	25608	0	
B					
2.2.2.2/32	10.10.10.2	Established	impl-null	0	
P					
3.3.3.3/32	connected	Established	25608	0	
3.3.3.3/32	10.10.10.2	Established	25608	0	
B					
3.3.3.3/32	connected	Established	25609	0	
3.3.3.3/32	20.20.20.2	Established	impl-null	0	
P					
4.4.4.4/32	connected	Established	25609	0	
4.4.4.4/32	10.10.10.2	Established	25609	0	
B					
4.4.4.4/32	20.20.20.2	Established	25609	0	
P					
4.4.4.4/32	connected	Established	impl-null	0	
5.5.5.5/32	connected	Established	25610	0	
5.5.5.5/32	20.20.20.2	Established	25610	0	
P					
5.5.5.5/32	connected	Established	25600	0	
5.5.5.5/32	10.10.10.2	Established	25600	0	
B					
10.10.10.0/24	connected	Established	impl-null	0	
10.10.10.0/24	connected	Established	none	0	None
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	none	0	None
20.20.20.0/24	connected	Established	impl-null	0	
20.20.20.0/24	connected	Established	none	0	None
30.30.30.0/24	connected	Established	25610	0	
30.30.30.0/24	connected	Established	25611	0	
30.30.30.0/24	connected	Established	impl-null	0	
30.30.30.0/24	connected	Established	none	0	None
40.40.40.0/24	connected	Established	25611	0	
40.40.40.0/24	connected	Established	25612	0	
40.40.40.0/24	20.20.20.2	Established	25612	0	
B					
40.40.40.0/24	10.10.10.2	Established	impl-null	0	
P					
50.50.50.0/24	connected	Established	25611	0	
50.50.50.0/24	10.10.10.2	Established	25611	0	
B					
50.50.50.0/24	connected	Established	25612	0	
50.50.50.0/24	20.20.20.2	Established	impl-null	0	
P					

60.60.60.0/24	connected	Established	25612	0
60.60.60.0/24	10.10.10.2	Established	25612	0
B 60.60.60.0/24	20.20.20.2	Established	25613	0
P 60.60.60.0/24	connected	Established	impl-null	0

UPSTREAM LSP :

FEC	State	Label	Req.ID	Attr
1.1.1.1/32	Established	impl-null	0	None
1.1.1.1/32	Established	impl-null	0	None
1.1.1.1/32	Established	impl-null	0	None
2.2.2.2/32	Established	25604	0	None
2.2.2.2/32	Established	25604	0	None
2.2.2.2/32	Established	25608	0	None
3.3.3.3/32	Established	25605	0	None
3.3.3.3/32	Established	25605	0	None
3.3.3.3/32	Established	25600	0	None
4.4.4.4/32	Established	25603	0	None
4.4.4.4/32	Established	25602	0	None
4.4.4.4/32	Established	25603	0	None
4.4.4.4/32	Established	25602	0	None
5.5.5.5/32	Established	25614	0	None
5.5.5.5/32	Established	25615	0	None
5.5.5.5/32	Established	25615	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
40.40.40.0/24	Established	25606	0	None
40.40.40.0/24	Established	25606	0	None
40.40.40.0/24	Established	25610	0	None
50.50.50.0/24	Established	25607	0	None
50.50.50.0/24	Established	25607	0	None
50.50.50.0/24	Established	25601	0	None
60.60.60.0/24	Established	25616	0	None
60.60.60.0/24	Established	25616	0	None
60.60.60.0/24	Established	25617	0	None
60.60.60.0/24	Established	25617	0	None

PE1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2	2	-	No	LSP_DEFAULT	25608
xe2	No	20.20.20.2	3	-	Yes	LSP_DEFAULT	3
L>	3.3.3.3/32	5	4	-	No	LSP_DEFAULT	25608
xe2	No	20.20.20.2	7	-	Yes	LSP_DEFAULT	25609
xe1	No	10.10.10.2	8	-	No	LSP_DEFAULT	25609
L>	4.4.4.4/32	3	5	-	Yes	LSP_DEFAULT	25610
xe2	No	20.20.20.2	9	-	No	LSP_DEFAULT	25600
xe1	No	10.10.10.2	1	-	Yes	LSP_DEFAULT	3
L>	40.40.40.0/24	2	10	-	No	LSP_DEFAULT	25612
xe1	No	10.10.10.2	3	-	Yes	LSP_DEFAULT	3
L>	50.50.50.0/24	6	11	-	No	LSP_DEFAULT	25611
xe2	No	20.20.20.2	6	-	Yes	LSP_DEFAULT	25613
xe1	No	10.10.10.2	12	-	No	LSP_DEFAULT	25612

PE1#show mpls forwarding-table 5.5.5.5/32

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	5.5.5.5/32	7	5	-	Yes	LSP_DEFAULT	25610
xe2	No	20.20.20.2	9	-	No	LSP_DEFAULT	25600
xe1	No	10.10.10.2					

PE1#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
 none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 2

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xe2, out label: 25608

Nexthop addr: 20.20.20.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Backup Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 4

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25608

Nexthop addr: 10.10.10.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609

Nexthop addr: 20.20.20.2 cross connect ix: 2, op code: Push

Backup Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609

Nexthop addr: 10.10.10.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610

Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Backup Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
Nexthop addr: 10.10.10.2 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 10

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 10, owner: LDP, Stale: NO, out intf: xe2, out label: 25612

Nexthop addr: 20.20.20.2 cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Backup Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 11

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25611

Nexthop addr: 10.10.10.2 cross connect ix: 11, op code: Push

Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613

Nexthop addr: 20.20.20.2 cross connect ix: 6, op code: Push

Backup Cross connect ix: 13, in intf: - in label: 0 out-segment ix: 12

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe1, out label: 25612
 Nexthop addr: 10.10.10.2 cross connect ix: 13, op code: Push

PE1#show mpls ftn-table 5.5.5.5/32

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
 none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610

Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Backup Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600

Nexthop addr: 10.10.10.2 cross connect ix: 7, op code: Push

PE1#show ldp fec prefix 5.5.5.5/32

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 P - Primary route, B - LFA Backup route,
 R - Remote LFA Backup route,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NLP>	3.3.3.3	25610	No	20.20.20.2
	NLB>	2.2.2.2	25600	No	10.10.10.2

PE1#show ip route fast-reroute

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP

O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area ,p -
 stale info, E - EVPN

* - candidate default

IP Route Table for VRF "default"

i L1 2.2.2.2/32 [115/30] via 10.10.10.2, xe1, 00:52:13
 [FRR-NH] via 20.20.20.2, xe2

i L1 3.3.3.3/32 [115/25] via 20.20.20.2, xe2, 00:50:43
 [FRR-NH] via 10.10.10.2, xe1

i L1 4.4.4.4/32 [115/45] via 20.20.20.2, xe2, 00:49:03
 [FRR-NH] via 10.10.10.2, xe1

```
i L1      5.5.5.5/32 [115/35] via 20.20.20.2, xe2, 00:49:53
          [FRR-NH] via 10.10.10.2, xe1

i L1      40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 00:49:53
          [FRR-NH] via 20.20.20.2, xe2

i L1      50.50.50.0/24 [115/25] via 20.20.20.2, xe2, 00:49:53
          [FRR-NH] via 10.10.10.2, xe1

i L1      60.60.60.0/24 [115/35] via 20.20.20.2, xe2, 00:49:53
          [FRR-NH] via 10.10.10.2, xe1
```

```
PE1#show ip isis route fast-reroute
```

```
Tag       : 1   VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        D - discard, LP - Link Protecting, NP - Node Protecting,
        BP - Broadcast Interface Disjoint, Pri - Primary Path,
        Sec - Secondary Path, DP - Downstream Path
```

```
L1  2.2.2.2/32
    Primary Path via      : 10.10.10.2, xe1
    FRR Backup Path via   : 20.20.20.2, xe2
    FRR Metric            : 45
    Protection Provided   : LP BP
```

```
L1  3.3.3.3/32
    Primary Path via      : 20.20.20.2, xe2
    FRR Backup Path via   : 10.10.10.2, xe1
    FRR Metric            : 50
    Protection Provided   : LP BP
```

```
L1  4.4.4.4/32
    Primary Path via      : 20.20.20.2, xe2
    FRR Backup Path via   : 10.10.10.2, xe1
    FRR Metric            : 50
    Protection Provided   : LP NP BP DP
```

```
L1  5.5.5.5/32
    Primary Path via      : 20.20.20.2, xe2
    FRR Backup Path via   : 10.10.10.2, xe1
    FRR Metric            : 40
    Protection Provided   : LP NP BP DP
```

```
L1  40.40.40.0/24
    Primary Path via      : 10.10.10.2, xe1
    FRR Backup Path via   : 20.20.20.2, xe2
    FRR Metric            : 35
    Protection Provided   : LP NP BP DP
```

```
L1 50.50.50.0/24
  Primary Path via      : 20.20.20.2, xe2
  FRR Backup Path via   : 10.10.10.2, xe1
  FRR Metric            : 40
  Protection Provided   : LP NP BP DP
```

```
L1 60.60.60.0/24
  Primary Path via      : 20.20.20.2, xe2
  FRR Backup Path via   : 10.10.10.2, xe1
  FRR Metric            : 40
  Protection Provided   : LP NP BP DP
```

```
PE1#show ldp routes
```

Prefix Addr	Nexthop Addr	Intf	Backup Addr	Backup Intf	Owner
0.0.0.0/0	10.12.49.1	xe0	-	-	kernel
1.1.1.1/32	0.0.0.0	lo	-	-	connected
2.2.2.2/32	10.10.10.2	xe1	20.20.20.2	xe2	isis
3.3.3.3/32	20.20.20.2	xe2	10.10.10.2	xe1	isis
4.4.4.4/32	20.20.20.2	xe2	10.10.10.2	xe1	isis
5.5.5.5/32	20.20.20.2	xe2	10.10.10.2	xe1	isis
10.10.10.0/24	0.0.0.0	xe1	-	-	connected
10.12.49.0/24	0.0.0.0	xe0	-	-	connected
20.20.20.0/24	0.0.0.0	xe2	-	-	connected
30.30.30.0/24	0.0.0.0	xe3	-	-	connected
40.40.40.0/24	10.10.10.2	xe1	20.20.20.2	xe2	isis
50.50.50.0/24	20.20.20.2	xe2	10.10.10.2	xe1	isis
60.60.60.0/24	20.20.20.2	xe2	10.10.10.2	xe1	isis

```
PE1#show mpls forwarding-table
```

```
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2					
			2	-	No	LSP_DEFAULT	25608
xe2	No	20.20.20.2					
L>	3.3.3.3/32	5	3	-	Yes	LSP_DEFAULT	3
xe2	No	20.20.20.2					
			4	-	No	LSP_DEFAULT	25608
xe1	No	10.10.10.2					
L>	4.4.4.4/32	3	7	-	Yes	LSP_DEFAULT	25609
xe2	No	20.20.20.2					
			8	-	No	LSP_DEFAULT	25609
xe1	No	10.10.10.2					
L>	5.5.5.5/32	7	5	-	Yes	LSP_DEFAULT	25610
xe2	No	20.20.20.2					
			9	-	No	LSP_DEFAULT	25600
xe1	No	10.10.10.2					

```

L> 40.40.40.0/24      2      1      -      Yes  LSP_DEFAULT  3
xe1      No      10.10.10.2
                                     10      -      No  LSP_DEFAULT  25612
xe2      No      20.20.20.2
L> 50.50.50.0/24      6      3      -      Yes  LSP_DEFAULT  3
xe2      No      20.20.20.2
                                     11      -      No  LSP_DEFAULT  25611
xe1      No      10.10.10.2
L> 60.60.60.0/24      4      6      -      Yes  LSP_DEFAULT  25613
xe2      No      20.20.20.2
                                     12      -      No  LSP_DEFAULT  25612
xe1      No      10.10.10.2

```

PE1#show mpls forwarding-table 5.5.5.5/32

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	5.5.5.5/32	7	5	-	Yes	LSP_DEFAULT	25610
xe2	No	20.20.20.2					
			9	-	No	LSP_DEFAULT	25600
xe1	No	10.10.10.2					

PE1#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 2

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xe2, out label: 25608

Nexthop addr: 20.20.20.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Backup Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25608
Nexthop addr: 10.10.10.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
Nexthop addr: 20.20.20.2 cross connect ix: 2, op code: Push

Backup Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609
Nexthop addr: 10.10.10.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Backup Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
Nexthop addr: 10.10.10.2 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 10
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 10, owner: LDP, Stale: NO, out intf: xe2, out label: 25612
Nexthop addr: 20.20.20.2 cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Backup Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 11

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25611

Nexthop addr: 10.10.10.2 cross connect ix: 11, op code: Push

Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613

Nexthop addr: 20.20.20.2 cross connect ix: 6, op code: Push

Backup Cross connect ix: 13, in intf: - in label: 0 out-segment ix: 12

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe1, out label: 25612

Nexthop addr: 10.10.10.2 cross connect ix: 13, op code: Push

PE1#show mpls ftn-table 5.5.5.5/32

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610

Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Backup Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
 Nexthop addr: 10.10.10.2 cross connect ix: 7, op code: Push

PE1#show ldp fec prefix 5.5.5.5/32

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 P - Primary route, B - LFA Backup route,
 R - Remote LFA Backup route,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NLP>	3.3.3.3	25610	No	20.20.20.2
	NLB>	2.2.2.2	25600	No	10.10.10.2

To prohibit an interface from being used as a repair path, disable fast reroute calculation on the interface:

#configure terminal	Enter configuration mode.
(config)#interface xe1	Enter interface mode.
(config-if)#isis fast-reroute per-prefix candidate disable level-1	Disable fast reroute calculation on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit all the configurations

Verify that the xe1 interface is not used for backup path calculation.

PE1#show clns neighbors

Total number of L1 adjacencies: 3
 Total number of L2 adjacencies: 0
 Total number of adjacencies: 3
 Tag 1: VRF : default

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
P1	xe1	5254.0002.5b0a	Up	22	L1	IS-IS
P2	xe2	5254.009b.f9a2	Up	8	L1	IS-IS
P3	xe3	5254.005d.e995	Up	6	L1	IS-IS

PE1#show clns neighbors detail

Total number of L1 adjacencies: 3
 Total number of L2 adjacencies: 0
 Total number of adjacencies: 3
 Tag 1: VRF : default

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
P1	xe1	5254.0002.5b0a	Up	20	L1	IS-IS

L1 Adjacency ID: 1
 L2 Adjacency ID: 2
 Uptime: 00:57:18
 Area Address(es): 49.0001
 IP Address(es): 10.10.10.2

```
Level-1 Protocols Supported: IPv4
Bidirectional Forwarding Detection is enabled
Adjacency advertisement: Advertise
P2          xe2          5254.009b.f9a2          Up          6          L1    IS-IS
L1  Adjacency ID: 1
L2  Adjacency ID: 2
Uptime: 00:56:54
Area Address(es): 49.0001
IP Address(es): 20.20.20.2
Level-1 Protocols Supported: IPv4
Bidirectional Forwarding Detection is enabled
Adjacency advertisement: Advertise
P3          xe3          5254.005d.e995          Up          8          L1    IS-IS
L1  Adjacency ID: 1
L2  Adjacency ID: 2
Uptime: 00:56:29
Area Address(es): 49.0001
IP Address(es): 30.30.30.2
Level-1 Protocols Supported: IPv4
Bidirectional Forwarding Detection is enabled
Adjacency advertisement: Advertise
```

```
PE1#show isis database
```

```
Tag 1: VRF : default
```

```
IS-IS Level-1 Link State Database:
```

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
PE1.00-00	* 0x0000000D	0xD5A2	523	0/0/0
PE1.02-00	* 0x00000004	0x8246	462	0/0/0
P1.00-00	0x0000000B	0xBC5A	590	0/0/0
P1.03-00	0x00000004	0xB80A	549	0/0/0
P2.00-00	0x0000000A	0xFC55	593	0/0/0
P2.02-00	0x00000004	0x7055	485	0/0/0
P2.03-00	0x00000004	0xB907	579	0/0/0
P3.00-00	0x0000000A	0xDBB1	614	0/0/0
P3.02-00	0x00000004	0x7152	500	0/0/0
PE2.00-00	0x0000000D	0xDD02	610	0/0/0
PE2.04-00	0x00000004	0xA01C	609	0/0/0

```
PE1#show isis database verbose
```

```
Tag 1: VRF : default
```

```
IS-IS Level-1 Link State Database:
```

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
PE1.00-00	* 0x0000000D	0xD5A2	513	0/0/0

```
Area Address: 49.0001
NLPID:       0xCC
Hostname:    PE1
IP Address:  1.1.1.1
Router ID:   10.12.49.172
Metric:      20          IS-Extended PE1.02
```

```

IPv4 Interface Address: 10.10.10.1
Neighbor IP Address: 10.10.10.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 20
Metric: 15          IS-Extended P2.02
IPv4 Interface Address: 20.20.20.1
Neighbor IP Address: 20.20.20.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 15
Metric: 60          IS-Extended P3.02
IPv4 Interface Address: 30.30.30.1
Neighbor IP Address: 30.30.30.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 60
Metric: 10          IP-Extended 1.1.1.1/32
Metric: 20          IP-Extended 10.10.10.0/24
Metric: 15          IP-Extended 20.20.20.0/24
Metric: 60          IP-Extended 30.30.30.0/24
PE1.02-00          * 0x00000004 0x8246          452          0/0/0
Metric: 0          IS-Extended PE1.00

```

```
Metric: 0          IS-Extended P1.00
P1.00-00          0x0000000B  0xBC5A          580          0/0/0
Area Address: 49.0001
NLPID:           0xCC
Hostname:        P1
IP Address:      2.2.2.2
Router ID:       10.12.49.173
Metric: 10        IS-Extended PE1.02
  IPv4 Interface Address: 10.10.10.2
  Neighbor IP Address: 10.10.10.1
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 10
Metric: 10          IS-Extended P1.03
  IPv4 Interface Address: 40.40.40.1
  Neighbor IP Address: 40.40.40.1
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 10
Metric: 10          IP-Extended 2.2.2.2/32
Metric: 10          IP-Extended 10.10.10.0/24
Metric: 10          IP-Extended 40.40.40.0/24
P1.03-00          0x00000004  0xB80A          540          0/0/0
  Metric: 0          IS-Extended P1.00
  Metric: 0          IS-Extended PE2.00
P2.00-00          0x0000000A  0xFC55          584          0/0/0
Area Address: 49.0001
NLPID:           0xCC
Hostname:        P2
IP Address:      3.3.3.3
Router ID:       10.12.49.176
Metric: 10        IS-Extended P2.02
```

```

IPv4 Interface Address: 20.20.20.2
Neighbor IP Address: 20.20.20.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IS-Extended P2.03
IPv4 Interface Address: 50.50.50.1
Neighbor IP Address: 50.50.50.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IP-Extended 3.3.3.3/32
Metric: 10          IP-Extended 50.50.50.0/24
Metric: 10          IP-Extended 20.20.20.0/24
P2.02-00            0x00000004    0x7055          476          0/0/0
Metric: 0           IS-Extended P2.00
Metric: 0           IS-Extended PE1.00
P2.03-00            0x00000004    0xB907          570          0/0/0
Metric: 0           IS-Extended P2.00
Metric: 0           IS-Extended PE2.00
P3.00-00            0x0000000A    0xDBB1          605          0/0/0
Area Address: 49.0001
NLPID:              0xCC
Hostname:           P3
IP Address:         4.4.4.4
Router ID:          10.12.49.177
Metric: 10          IS-Extended P3.02
IPv4 Interface Address: 30.30.30.2
Neighbor IP Address: 30.30.30.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:

```

```
Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IS-Extended PE2.04
IPv4 Interface Address: 60.60.60.1
Neighbor IP Address: 60.60.60.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IP-Extended 4.4.4.4/32
Metric: 10          IP-Extended 60.60.60.0/24
Metric: 10          IP-Extended 30.30.30.0/24
P3.02-00            0x00000004  0x7152          491          0/0/0
Metric: 0           IS-Extended P3.00
Metric: 0           IS-Extended PE1.00
PE2.00-00            0x0000000D  0xDD02          601          0/0/0
Area Address: 49.0001
NLPID: 0xCC
Hostname: PE2
IP Address: 5.5.5.5
Router ID: 10.12.49.174
Metric: 10          IS-Extended P1.03
IPv4 Interface Address: 40.40.40.2
Neighbor IP Address: 40.40.40.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
```



```

TE-Default Metric: 10
Metric: 10          IS-Extended P2.03
IPv4 Interface Address: 50.50.50.2
Neighbor IP Address: 50.50.50.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IS-Extended PE2.04
IPv4 Interface Address: 60.60.60.2
Neighbor IP Address: 60.60.60.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10          IP-Extended 5.5.5.5/32
Metric: 10          IP-Extended 60.60.60.0/24
Metric: 10          IP-Extended 50.50.50.0/24
Metric: 10          IP-Extended 40.40.40.0/24
PE2.04-00          0x00000004  0xA01C          600          0/0/0
Metric: 0          IS-Extended PE2.00
Metric: 0          IS-Extended P3.00

PE1#show ldp session
Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
5.5.5.5              xe3        Passive    OPERATIONAL 30         00:55:24
2.2.2.2              xe1        Passive    OPERATIONAL 30         00:57:26
3.3.3.3              xe2        Passive    OPERATIONAL 30         00:56:38
4.4.4.4              xe3        Passive    OPERATIONAL 30         00:56:45

PE1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

```

E1 - OSPF external type 1, E2 - OSPF external type 2
 i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
 ia - IS-IS inter area, E - EVPN,
 v - vrf leaked
 * - candidate default

IP Route Table for VRF "default"

Gateway of last resort is 10.12.49.1 to network 0.0.0.0

```
K*      0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C       1.1.1.1/32 is directly connected, lo, 01:06:01
i L1    2.2.2.2/32 [115/30] via 10.10.10.2, xe1, 00:58:02
i L1    3.3.3.3/32 [115/25] via 20.20.20.2, xe2, 00:56:32
i L1    4.4.4.4/32 [115/45] via 20.20.20.2, xe2, 00:54:52
i L1    5.5.5.5/32 [115/35] via 20.20.20.2, xe2, 00:55:42
C       10.10.10.0/24 is directly connected, xe1, 01:06:01
C       10.12.49.0/24 is directly connected, xe0, 01:10:40
C       20.20.20.0/24 is directly connected, xe2, 01:06:01
C       30.30.30.0/24 is directly connected, xe3, 01:06:01
i L1    40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 00:55:42
i L1    50.50.50.0/24 [115/25] via 20.20.20.2, xe2, 00:55:42
i L1    60.60.60.0/24 [115/35] via 20.20.20.2, xe2, 00:55:42
C       127.0.0.0/8 is directly connected, lo, 03:41:51
```

PE1#show ip route summary

```
-----
IP routing table name is Default-IP-Routing-Table(0)
-----
```

```
IP routing table maximum-paths      : 8
Total number of IPv4 routes         : 14
Total number of IPv4 paths          : 14
Pending routes (due to route max reached): 0
Route Source      Networks
kernel            1
connected         6
isis              7
Total             14
FIB               14
```

ECMP statistics (active in ASIC):

```
Total number of IPv4 ECMP routes : 0
Total number of IPv4 ECMP paths  : 0
```

LFA Non ECMP statistics

```
-----
Total number of Routes      : 7
Total number of Primary Paths : 7
Total number of Backup Paths : 7
```

```
PE1#show ip interface brief
```

'*' - address is assigned by dhcp client

Interface	IP-Address	Admin-Status	Link-Status
xe0	*10.12.49.172	up	up
xe1	unassigned	up	up
xe1	10.10.10.1	up	up
xe3	unassigned	up	up
xe4	unassigned	up	up
xe5	unassigned	up	up
xe6	unassigned	up	up
xe7	unassigned	up	up
xe8	unassigned	up	up
xe9	unassigned	up	up
xe10	unassigned	up	up
xe11	unassigned	up	up
xe2	20.20.20.1	up	up
xe3	30.30.30.1	up	up
lo	127.0.0.1	up	up

```
PE1#show ip isis route fast-reroute
```

Tag : 1 VRF : default

Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
D - discard, LP - Link Protecting, NP - Node Protecting,
BP - Broadcast Interface Disjoint, Pri - Primary Path,
Sec - Secondary Path, DP - Downstream Path

L1 2.2.2.2/32
Primary Path via : 10.10.10.2, xe1
FRR Backup Path via : 30.30.30.2, xe3
FRR Metric : 90
Protection Provided : LP BP

L1 3.3.3.3/32
Primary Path via : 20.20.20.2, xe2
FRR Backup Path via : 10.10.10.2, xe1
FRR Metric : 50
Protection Provided : LP BP

L1 4.4.4.4/32
Primary Path via : 20.20.20.2, xe2
FRR Backup Path via : 10.10.10.2, xe1
FRR Metric : 50
Protection Provided : LP NP BP DP

L1 5.5.5.5/32

Primary Path via : 20.20.20.2, xe2
 FRR Backup Path via : 10.10.10.2, xe1
 FRR Metric : 40
 Protection Provided : LP NP BP DP

L1 40.40.40.0/24

Primary Path via : 10.10.10.2, xe1
 FRR Backup Path via : 30.30.30.2, xe3
 FRR Metric : 80
 Protection Provided : LP NP BP DP

L1 50.50.50.0/24

Primary Path via : 20.20.20.2, xe2
 FRR Backup Path via : 10.10.10.2, xe1
 FRR Metric : 40
 Protection Provided : LP NP BP DP

L1 60.60.60.0/24

Primary Path via : 20.20.20.2, xe2
 FRR Backup Path via : 10.10.10.2, xe1
 FRR Metric : 40
 Protection Provided : LP NP BP DP

PE1#show ldp routes

Prefix Addr	Nexthop Addr	Intf	Backup Addr	Backup Intf	Owner
0.0.0.0/0	10.12.49.1	xe0	-	-	kernel
1.1.1.1/32	0.0.0.0	lo	-	-	connected
2.2.2.2/32	10.10.10.2	xe1	30.30.30.2	xe3	isis
3.3.3.3/32	20.20.20.2	xe2	10.10.10.2	xe1	isis
4.4.4.4/32	20.20.20.2	xe2	10.10.10.2	xe1	isis
5.5.5.5/32	20.20.20.2	xe2	10.10.10.2	xe1	isis
10.10.10.0/24	0.0.0.0	xe1	-	-	connected
10.12.49.0/24	0.0.0.0	xe0	-	-	connected
20.20.20.0/24	0.0.0.0	xe2	-	-	connected
30.30.30.0/24	0.0.0.0	xe3	-	-	connected
40.40.40.0/24	10.10.10.2	xe1	30.30.30.2	xe3	isis
50.50.50.0/24	20.20.20.2	xe2	10.10.10.2	xe1	isis
60.60.60.0/24	20.20.20.2	xe2	10.10.10.2	xe1	isis

PE1#show ldp fec

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 P - Primary route, B - LFA Backup route,
 R - Remote LFA Backup route,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	E >	non-existent	none	No	connected
2.2.2.2/32	NLB>	4.4.4.4	25608	No	30.30.30.2
	NL	3.3.3.3	25608	No	no nexthop
	NLP>	2.2.2.2	impl-null	No	10.10.10.2

3.3.3.3/32	NLB>	2.2.2.2	25608	No	10.10.10.2
	NL	4.4.4.4	25609	No	no nexthop
	NLP>	3.3.3.3	impl-null	No	20.20.20.2
4.4.4.4/32	NLB>	2.2.2.2	25609	No	10.10.10.2
	NLP>	3.3.3.3	25609	No	20.20.20.2
	NL	4.4.4.4	impl-null	No	no nexthop
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NLP>	3.3.3.3	25610	No	20.20.20.2
	NLB>	2.2.2.2	25600	No	10.10.10.2
10.10.10.0/24	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
10.12.49.0/24	NL	3.3.3.3	impl-null	No	connected
	NL	4.4.4.4	impl-null	No	connected
	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
	NL	3.3.3.3	impl-null	No	connected
20.20.20.0/24	E >	non-existent	none	No	connected
	NL	3.3.3.3	impl-null	No	connected
30.30.30.0/24	NL	2.2.2.2	25610	No	connected
	NL	3.3.3.3	25611	No	connected
	NL	4.4.4.4	impl-null	No	connected
	E >	non-existent	none	No	connected
40.40.40.0/24	NLB>	4.4.4.4	25611	No	30.30.30.2
	NL	3.3.3.3	25612	No	no nexthop
	NLP>	2.2.2.2	impl-null	No	10.10.10.2
50.50.50.0/24	NLB>	2.2.2.2	25611	No	10.10.10.2
	NL	4.4.4.4	25612	No	no nexthop
	NLP>	3.3.3.3	impl-null	No	20.20.20.2
60.60.60.0/24	NLB>	2.2.2.2	25612	No	10.10.10.2
	NLP>	3.3.3.3	25613	No	20.20.20.2
	NL	4.4.4.4	impl-null	No	no nexthop

PE1#show ldp downstream

Codes: P - Primary route, B - Backup route

Session peer 5.5.5.5:

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
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Codes: P - Primary route, B - Backup route

Session peer 2.2.2.2:

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
60.60.60.0/24	connected	Established	25612	0	
60.60.60.0/24	10.10.10.2	Established	25612	0	
B 50.50.50.0/24	connected	Established	25611	0	
50.50.50.0/24	10.10.10.2	Established	25611	0	
B 30.30.30.0/24	connected	Established	25610	0	
4.4.4.4/32	connected	Established	25609	0	
4.4.4.4/32	10.10.10.2	Established	25609	0	
B 3.3.3.3/32	connected	Established	25608	0	

```

3.3.3.3/32      10.10.10.2      Established      25608      0
B
5.5.5.5/32      connected      Established      25600      0
5.5.5.5/32      10.10.10.2      Established      25600      0
B
40.40.40.0/24   10.10.10.2      Established      impl-null   0
P
10.12.49.0/24   connected      Established      impl-null   0
10.10.10.0/24   connected      Established      impl-null   0
2.2.2.2/32      10.10.10.2      Established      impl-null   0
P

```

Codes: P - Primary route, B - Backup route

Session peer 3.3.3.3:

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
40.40.40.0/24	connected	Established	25612	0	
30.30.30.0/24	connected	Established	25611	0	
4.4.4.4/32	20.20.20.2	Established	25609	0	
P 2.2.2.2/32	connected	Established	25608	0	
P 60.60.60.0/24	20.20.20.2	Established	25613	0	
P 5.5.5.5/32	20.20.20.2	Established	25610	0	
P 50.50.50.0/24	20.20.20.2	Established	impl-null	0	
20.20.20.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
P 3.3.3.3/32	20.20.20.2	Established	impl-null	0	

Codes: P - Primary route, B - Backup route

Session peer 4.4.4.4:

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
50.50.50.0/24	connected	Established	25612	0	
40.40.40.0/24	connected	Established	25611	0	
40.40.40.0/24	30.30.30.2	Established	25611	0	
B 5.5.5.5/32	connected	Established	25610	0	
3.3.3.3/32	connected	Established	25609	0	
2.2.2.2/32	connected	Established	25608	0	
B 2.2.2.2/32	30.30.30.2	Established	25608	0	
60.60.60.0/24	connected	Established	impl-null	0	
30.30.30.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
4.4.4.4/32	connected	Established	impl-null	0	

PE1#show ldp lsp

DOWNSTREAM LSP :

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
1.1.1.1/32	connected	Established	none	0	None
2.2.2.2/32	connected	Established	25608	0	

	2.2.2.2/32	30.30.30.2	Established	25608	0	
B	2.2.2.2/32	connected	Established	25608	0	
	2.2.2.2/32	10.10.10.2	Established	impl-null	0	
P	3.3.3.3/32	connected	Established	25608	0	
	3.3.3.3/32	10.10.10.2	Established	25608	0	
B	3.3.3.3/32	connected	Established	25609	0	
	3.3.3.3/32	20.20.20.2	Established	impl-null	0	
P	4.4.4.4/32	connected	Established	25609	0	
	4.4.4.4/32	10.10.10.2	Established	25609	0	
B	4.4.4.4/32	20.20.20.2	Established	25609	0	
P	4.4.4.4/32	connected	Established	impl-null	0	
	5.5.5.5/32	connected	Established	25610	0	
	5.5.5.5/32	20.20.20.2	Established	25610	0	
P	5.5.5.5/32	connected	Established	25600	0	
	5.5.5.5/32	10.10.10.2	Established	25600	0	
B	10.10.10.0/24	connected	Established	impl-null	0	
	10.10.10.0/24	connected	Established	none	0	None
	10.12.49.0/24	connected	Established	impl-null	0	
	10.12.49.0/24	connected	Established	impl-null	0	
	10.12.49.0/24	connected	Established	impl-null	0	
	10.12.49.0/24	connected	Established	none	0	None
	20.20.20.0/24	connected	Established	impl-null	0	
	20.20.20.0/24	connected	Established	none	0	None
	30.30.30.0/24	connected	Established	25610	0	
	30.30.30.0/24	connected	Established	25611	0	
	30.30.30.0/24	connected	Established	impl-null	0	
	30.30.30.0/24	connected	Established	none	0	None
	40.40.40.0/24	connected	Established	25611	0	
	40.40.40.0/24	30.30.30.2	Established	25611	0	
B	40.40.40.0/24	connected	Established	25612	0	
	40.40.40.0/24	10.10.10.2	Established	impl-null	0	
P	50.50.50.0/24	connected	Established	25611	0	
	50.50.50.0/24	10.10.10.2	Established	25611	0	
B	50.50.50.0/24	connected	Established	25612	0	
	50.50.50.0/24	20.20.20.2	Established	impl-null	0	
P	60.60.60.0/24	connected	Established	25612	0	
	60.60.60.0/24	10.10.10.2	Established	25612	0	
B	60.60.60.0/24	20.20.20.2	Established	25613	0	
P	60.60.60.0/24	connected	Established	impl-null	0	

UPSTREAM LSP :

FEC	State	Label	Req.ID	Attr
1.1.1.1/32	Established	impl-null	0	None
1.1.1.1/32	Established	impl-null	0	None
1.1.1.1/32	Established	impl-null	0	None
2.2.2.2/32	Established	25608	0	None
2.2.2.2/32	Established	25604	0	None
2.2.2.2/32	Established	25604	0	None
2.2.2.2/32	Established	25608	0	None
3.3.3.3/32	Established	25605	0	None
3.3.3.3/32	Established	25605	0	None
3.3.3.3/32	Established	25600	0	None
4.4.4.4/32	Established	25603	0	None
4.4.4.4/32	Established	25602	0	None
4.4.4.4/32	Established	25603	0	None
4.4.4.4/32	Established	25602	0	None
5.5.5.5/32	Established	25614	0	None
5.5.5.5/32	Established	25615	0	None
5.5.5.5/32	Established	25615	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
40.40.40.0/24	Established	25610	0	None
40.40.40.0/24	Established	25606	0	None
40.40.40.0/24	Established	25606	0	None
40.40.40.0/24	Established	25610	0	None
50.50.50.0/24	Established	25607	0	None
50.50.50.0/24	Established	25607	0	None
50.50.50.0/24	Established	25601	0	None
60.60.60.0/24	Established	25616	0	None
60.60.60.0/24	Established	25616	0	None
60.60.60.0/24	Established	25617	0	None
60.60.60.0/24	Established	25617	0	None

PE1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC		FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop						


```

L> 2.2.2.2/32 1 1 - Yes LSP_DEFAULT 3
xe1 No 10.10.10.2
13 - No LSP_DEFAULT 25608
xe3 No 30.30.30.2
L> 3.3.3.3/32 5 3 - Yes LSP_DEFAULT 3
xe2 No 20.20.20.2
4 - No LSP_DEFAULT 25608
xe1 No 10.10.10.2
L> 4.4.4.4/32 3 7 - Yes LSP_DEFAULT 25609
xe2 No 20.20.20.2
8 - No LSP_DEFAULT 25609
xe1 No 10.10.10.2
L> 5.5.5.5/32 7 5 - Yes LSP_DEFAULT 25610
xe2 No 20.20.20.2
9 - No LSP_DEFAULT 25600
xe1 No 10.10.10.2
L> 40.40.40.0/24 2 1 - Yes LSP_DEFAULT 3
xe1 No 10.10.10.2
14 - No LSP_DEFAULT 25611
xe3 No 30.30.30.2
L> 50.50.50.0/24 6 3 - Yes LSP_DEFAULT 3
xe2 No 20.20.20.2
11 - No LSP_DEFAULT 25611
xe1 No 10.10.10.2
L> 60.60.60.0/24 4 6 - Yes LSP_DEFAULT 25613
xe2 No 20.20.20.2
12 - No LSP_DEFAULT 25612
xe1 No 10.10.10.2

```

PE1#show mpls forwarding-table 5.5.5.5/32

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	5.5.5.5/32	7	5	-	Yes	LSP_DEFAULT	25610
xe2	No	20.20.20.2					
			9	-	No	LSP_DEFAULT	25600
xe1	No	10.10.10.2					

PE1#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 13

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 13, owner: LDP, Stale: NO, out intf: xe3, out label: 25608
Nexthop addr: 30.30.30.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Backup Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25608
Nexthop addr: 10.10.10.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
Nexthop addr: 20.20.20.2 cross connect ix: 2, op code: Push

Backup Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609
Nexthop addr: 10.10.10.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Backup Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
Nexthop addr: 10.10.10.2 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 14

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 14, owner: LDP, Stale: NO, out intf: xe3, out label: 25611

Nexthop addr: 30.30.30.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Backup Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 11

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25611

Nexthop addr: 10.10.10.2 cross connect ix: 11, op code: Push

Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613

Nexthop addr: 20.20.20.2 cross connect ix: 6, op code: Push

Backup Cross connect ix: 13, in intf: - in label: 0 out-segment ix: 12

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe1, out label: 25612

Nexthop addr: 10.10.10.2 cross connect ix: 13, op code: Push

PE1#show mpls ftn-table 5.5.5.5/32

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610

Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Backup Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600

Nexthop addr: 10.10.10.2 cross connect ix: 7, op code: Push

PE1#show ldp fec prefix 5.5.5.5/32

LSR codes : E/N - LSR is egress/non-egress for this FEC,
L - LSR received a label for this FEC,
P - Primary route, B - LFA Backup route,
R - Remote LFA Backup route,
> - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NLP>	3.3.3.3	25610	No	20.20.20.2
	NLB>	2.2.2.2	25600	No	10.10.10.2

PE1#show ip route fast-reroute

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP

O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area ,p - stale info, E - EVPN

* - candidate default

IP Route Table for VRF "default"

i L1 2.2.2.2/32 [115/30] via 10.10.10.2, xe1, 00:59:29
[FRR-NH] via 30.30.30.2, xe3

i L1 3.3.3.3/32 [115/25] via 20.20.20.2, xe2, 00:57:59
[FRR-NH] via 10.10.10.2, xe1

i L1 4.4.4.4/32 [115/45] via 20.20.20.2, xe2, 00:56:19
[FRR-NH] via 10.10.10.2, xe1

i L1 5.5.5.5/32 [115/35] via 20.20.20.2, xe2, 00:57:09
[FRR-NH] via 10.10.10.2, xe1

```
i L1      40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 00:57:09
          [FRR-NH] via 30.30.30.2, xe3

i L1      50.50.50.0/24 [115/25] via 20.20.20.2, xe2, 00:57:09
          [FRR-NH] via 10.10.10.2, xe1

i L1      60.60.60.0/24 [115/35] via 20.20.20.2, xe2, 00:57:09
          [FRR-NH] via 10.10.10.2, xe1
```

```
PE1#show ip isis route fast-reroute
```

```
Tag      : 1   VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        D - discard, LP - Link Protecting, NP - Node Protecting,
        BP - Broadcast Interface Disjoint, Pri - Primary Path,
        Sec - Secondary Path, DP - Downstream Path
```

```
L1  2.2.2.2/32
    Primary Path via      : 10.10.10.2, xe1
    FRR Backup Path via   : 30.30.30.2, xe3
    FRR Metric            : 90
    Protection Provided   : LP BP
```

```
L1  3.3.3.3/32
    Primary Path via      : 20.20.20.2, xe2
    FRR Backup Path via   : 10.10.10.2, xe1
    FRR Metric            : 50
    Protection Provided   : LP BP
```

```
L1  4.4.4.4/32
    Primary Path via      : 20.20.20.2, xe2
    FRR Backup Path via   : 10.10.10.2, xe1
    FRR Metric            : 50
    Protection Provided   : LP NP BP DP
```

```
L1  5.5.5.5/32
    Primary Path via      : 20.20.20.2, xe2
    FRR Backup Path via   : 10.10.10.2, xe1
    FRR Metric            : 40
    Protection Provided   : LP NP BP DP
```

```
L1  40.40.40.0/24
    Primary Path via      : 10.10.10.2, xe1
    FRR Backup Path via   : 30.30.30.2, xe3
    FRR Metric            : 80
    Protection Provided   : LP NP BP DP
```

```
L1  50.50.50.0/24
    Primary Path via      : 20.20.20.2, xe2
    FRR Backup Path via   : 10.10.10.2, xe1
```

```
FRR Metric           : 40
Protection Provided  : LP NP BP DP
```

```
L1 60.60.60.0/24
Primary Path via      : 20.20.20.2, xe2
FRR Backup Path via   : 10.10.10.2, xe1
FRR Metric           : 40
Protection Provided  : LP NP BP DP
```

```
PE1#show ldp routes
```

Prefix Addr	Nexthop Addr	Intf	Backup Addr	Backup Intf	Owner
0.0.0.0/0	10.12.49.1	xe0	-	-	kernel
1.1.1.1/32	0.0.0.0	lo	-	-	connected
2.2.2.2/32	10.10.10.2	xe1	30.30.30.2	xe3	isis
3.3.3.3/32	20.20.20.2	xe2	10.10.10.2	xe1	isis
4.4.4.4/32	20.20.20.2	xe2	10.10.10.2	xe1	isis
5.5.5.5/32	20.20.20.2	xe2	10.10.10.2	xe1	isis
10.10.10.0/24	0.0.0.0	xe1	-	-	connected
10.12.49.0/24	0.0.0.0	xe0	-	-	connected
20.20.20.0/24	0.0.0.0	xe2	-	-	connected
30.30.30.0/24	0.0.0.0	xe3	-	-	connected
40.40.40.0/24	10.10.10.2	xe1	30.30.30.2	xe3	isis
50.50.50.0/24	20.20.20.2	xe2	10.10.10.2	xe1	isis
60.60.60.0/24	20.20.20.2	xe2	10.10.10.2	xe1	isis

```
PE1#show mpls forwarding-table
```

```
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2					
			13	-	No	LSP_DEFAULT	25608
xe3	No	30.30.30.2					
L>	3.3.3.3/32	5	3	-	Yes	LSP_DEFAULT	3
xe2	No	20.20.20.2					
			4	-	No	LSP_DEFAULT	25608
xe1	No	10.10.10.2					
L>	4.4.4.4/32	3	7	-	Yes	LSP_DEFAULT	25609
xe2	No	20.20.20.2					
			8	-	No	LSP_DEFAULT	25609
xe1	No	10.10.10.2					
L>	5.5.5.5/32	7	5	-	Yes	LSP_DEFAULT	25610
xe2	No	20.20.20.2					
			9	-	No	LSP_DEFAULT	25600
xe1	No	10.10.10.2					
L>	40.40.40.0/24	2	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2					

Interface	Next Hop	Distance	Label	Out-Label
xe3	No 30.30.30.2	14	-	No LSP_DEFAULT 25611
L>	50.50.50.0/24 6	3	-	Yes LSP_DEFAULT 3
xe2	No 20.20.20.2	11	-	No LSP_DEFAULT 25611
xe1	No 10.10.10.2	6	-	Yes LSP_DEFAULT 25613
L>	60.60.60.0/24 4	6	-	Yes LSP_DEFAULT 25613
xe2	No 20.20.20.2	12	-	No LSP_DEFAULT 25612
xe1	No 10.10.10.2			

PE1#show mpls forwarding-table 5.5.5.5/32

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	5.5.5.5/32	7	5	-	Yes	LSP_DEFAULT	25610
xe2	No 20.20.20.2		9	-	No	LSP_DEFAULT	25600
xe1	No 10.10.10.2						

PE1#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 13

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 13, owner: LDP, Stale: NO, out intf: xe3, out label: 25608

Nexthop addr: 30.30.30.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Backup Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 4

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25608
 Nexthop addr: 10.10.10.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
 none

...skipping 1 line

Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4
 Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
 Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
 Nexthop addr: 20.20.20.2 cross connect ix: 2, op code: Push

Backup Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
 Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609
 Nexthop addr: 10.10.10.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
 none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
 Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
 Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
 Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
 Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Backup Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9
 Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
 Nexthop addr: 10.10.10.2 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
 none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
 Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
 Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

--More--

Most commands optionally preceded by integer argument k. Defaults in brackets.
 Star (*) indicates argument becomes new default.

```
-----
<space>          Display next k lines of text [current screen size]
z                Display next k lines of text [current screen size]*
<return>        Display next k lines of text [1]*
```



```

d or ctrl-D      Scroll k lines [current scroll size, initially 11]*
q or Q or <interrupt> Exit from more
s               Skip forward k lines of text [1]
f               Skip forward k screenfuls of text [1]
b or ctrl-B     Skip backwards k screenfuls of text [1]
'              Go to place where previous search started
=              Display current line number
/<regular expression> Search for kth occurrence of regular expression [1]
n              Search for kth occurrence of last r.e [1]
!<cmd> or :!<cmd> Execute <cmd> in a subshell
v              Start up /usr/bin/vi at current line
ctrl-L         Redraw screen
:n             Go to kth next file [1]
:p             Go to kth previous file [1]
:f            Display current file name and line number
.             Repeat previous command

```

```

-----
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 10.10.10.2      cross connect ix:1, op code: Push

```

```

Backup Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 14
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 14, owner: LDP, Stale: NO, out intf: xe3, out label: 25611
Nexthop addr: 30.30.30.2      cross connect ix: 2, op code: Push

```

Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Backup Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 11

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25611

Nexthop addr: 10.10.10.2 cross connect ix: 11, op code: Push

Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613

...skipping 1 line

Backup Cross connect ix: 13, in intf: - in label: 0 out-segment ix: 12
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe1, out label: 25612
Nexthop addr: 10.10.10.2 cross connect ix: 13, op code: Push

PE1#show ldp fec prefix 5.5.5.5/32

LSR codes : E/N - LSR is egress/non-egress for this FEC,
L - LSR received a label for this FEC,
P - Primary route, B - LFA Backup route,
R - Remote LFA Backup route,
> - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NLP>	3.3.3.3	25610	No	20.20.20.2
	NLB>	2.2.2.2	25600	No	10.10.10.2

PE1#show mpls ftn-table 5.5.5.5/32

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610

Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Backup Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600

Nexthop addr: 10.10.10.2 cross connect ix: 7, op code: Push

PE1#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 13
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 13, owner: LDP, Stale: NO, out intf: xe3, out label: 25608
Nexthop addr: 30.30.30.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Backup Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25608
Nexthop addr: 10.10.10.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
Nexthop addr: 20.20.20.2 cross connect ix: 2, op code: Push

Backup Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609
Nexthop addr: 10.10.10.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Backup Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
Nexthop addr: 10.10.10.2 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 14

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 14, owner: LDP, Stale: NO, out intf: xe3, out label: 25611

Nexthop addr: 30.30.30.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Backup Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 11

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25611

Nexthop addr: 10.10.10.2 cross connect ix: 11, op code: Push

Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613

Nexthop addr: 20.20.20.2 cross connect ix: 6, op code: Push

Backup Cross connect ix: 13, in intf: - in label: 0 out-segment ix: 12

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe1, out label: 25612

Nexthop addr: 10.10.10.2

cross connect ix: 13, op code: Push

PE1#show ldp fec prefix 5.5.5.5/32

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 P - Primary route, B - LFA Backup route,
 R - Remote LFA Backup route,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NLP>	3.3.3.3	25610	No	20.20.20.2
	NLB>	2.2.2.2	25600	No	10.10.10.2

Backup Path based on Route-Map Prefixes

(config)#ip access-list A	Create an access-list
(config-ip-acl)#10 permit any host 40.40.40.0 any	Configuring rule to permit only one prefix
(config)#route-map R permit 10	Create a route-map
(config-route-map)#match ip address A	Apply above created access-list in route-map
(config-route-map)#exit	Exit route-map mode
(config)#commit	Commit all the configurations

Apply the above created route-map with fast-reroute:

(config)#router isis 1	Create an IS-IS routing instance for area 49 with instance 1
(config-router)#no fast-reroute per-prefix level-1 proto ipv4	Un-configure LFA-FRR to calculate available path for all prefixes
(config-router)#fast-reroute per-prefix level-1 proto ipv4 route-map R	Configure LFA-FRR to calculate the available backup path for routes allowed through route-map
(config-router)#exit	Exit router mode
(config)#commit	Commit all the configurations

Validation

PE1#show clns neighbors

Total number of L1 adjacencies: 3

Total number of L2 adjacencies: 0

Total number of adjacencies: 3

Tag 1: VRF : default

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
P1	xe1	5254.0002.5b0a	Up	28	L1	IS-IS
P2	xe2	5254.009b.f9a2	Up	7	L1	IS-IS

```
P3          xe3          5254.005d.e995      Up      5          L1    IS-IS
```

```
PE1#show clns neighbors detail
```

```
Total number of L1 adjacencies: 3
```

```
Total number of L2 adjacencies: 0
```

```
Total number of adjacencies: 3
```

```
Tag 1:  VRF : default
```

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
P1	xe1	5254.0002.5b0a	Up	26	L1	IS-IS

```
  L1  Adjacency ID: 1
```

```
  L2  Adjacency ID: 2
```

```
Uptime: 01:04:52
```

```
Area Address(es): 49.0001
```

```
IP Address(es): 10.10.10.2
```

```
Level-1 Protocols Supported: IPv4
```

```
Bidirectional Forwarding Detection is enabled
```

```
Adjacency advertisement: Advertise
```

```
P2          xe2          5254.009b.f9a2      Up      8          L1    IS-IS
```

```
  L1  Adjacency ID: 1
```

```
  L2  Adjacency ID: 2
```

```
Uptime: 01:04:28
```

```
Area Address(es): 49.0001
```

```
IP Address(es): 20.20.20.2
```

```
Level-1 Protocols Supported: IPv4
```

```
Bidirectional Forwarding Detection is enabled
```

```
Adjacency advertisement: Advertise
```

```
P3          xe3          5254.005d.e995      Up      7          L1    IS-IS
```

```
  L1  Adjacency ID: 1
```

```
  L2  Adjacency ID: 2
```

```
Uptime: 01:04:03
```

```
Area Address(es): 49.0001
```

```
IP Address(es): 30.30.30.2
```

```
Level-1 Protocols Supported: IPv4
```

```
Bidirectional Forwarding Detection is enabled
```

```
Adjacency advertisement: Advertise
```

```
PE1#show isis database
```

```
Tag 1:  VRF : default
```

```
IS-IS Level-1 Link State Database:
```

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
PE1.00-00	* 0x0000000E	0xD3A3	968	0/0/0
PE1.02-00	* 0x00000005	0x8047	908	0/0/0
P1.00-00	0x0000000C	0xBA5B	1035	0/0/0
P1.03-00	0x00000005	0xB60B	995	0/0/0
P2.00-00	0x0000000B	0xFA56	1039	0/0/0
P2.02-00	0x00000005	0x6E56	931	0/0/0
P2.03-00	0x00000005	0xB708	1025	0/0/0
P3.00-00	0x0000000B	0xD9B2	1060	0/0/0
P3.02-00	0x00000005	0x6F53	946	0/0/0

PE2.00-00	0x0000000E	0xDB03	1056	0/0/0
PE2.04-00	0x00000005	0x9E1D	1055	0/0/0

PE1#show isis database verbose

Tag 1: VRF : default

IS-IS Level-1 Link State Database:

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
PE1.00-00	* 0x0000000E	0xD3A3	963	0/0/0

Area Address: 49.0001

NLPID: 0xCC

Hostname: PE1

IP Address: 1.1.1.1

Router ID: 10.12.49.172

Metric: 20 IS-Extended PE1.02

IPv4 Interface Address: 10.10.10.1

Neighbor IP Address: 10.10.10.1

Maximum Link Bandwidth : 100000.00 kbits/sec

Reservable Bandwidth : 100000.00 kbits/sec

Unreserved Bandwidth:

Unreserved Bandwidth at priority 0: 100000.00 kbits/sec

Unreserved Bandwidth at priority 1: 100000.00 kbits/sec

Unreserved Bandwidth at priority 2: 100000.00 kbits/sec

Unreserved Bandwidth at priority 3: 100000.00 kbits/sec

Unreserved Bandwidth at priority 4: 100000.00 kbits/sec

Unreserved Bandwidth at priority 5: 100000.00 kbits/sec

Unreserved Bandwidth at priority 6: 100000.00 kbits/sec

Unreserved Bandwidth at priority 7: 100000.00 kbits/sec

TE-Default Metric: 20

Metric: 15 IS-Extended P2.02

IPv4 Interface Address: 20.20.20.1

Neighbor IP Address: 20.20.20.2

Maximum Link Bandwidth : 100000.00 kbits/sec

Reservable Bandwidth : 100000.00 kbits/sec

Unreserved Bandwidth:

Unreserved Bandwidth at priority 0: 100000.00 kbits/sec

Unreserved Bandwidth at priority 1: 100000.00 kbits/sec

Unreserved Bandwidth at priority 2: 100000.00 kbits/sec

Unreserved Bandwidth at priority 3: 100000.00 kbits/sec

Unreserved Bandwidth at priority 4: 100000.00 kbits/sec

Unreserved Bandwidth at priority 5: 100000.00 kbits/sec

Unreserved Bandwidth at priority 6: 100000.00 kbits/sec

Unreserved Bandwidth at priority 7: 100000.00 kbits/sec

TE-Default Metric: 15

Metric: 60 IS-Extended P3.02

IPv4 Interface Address: 30.30.30.1

Neighbor IP Address: 30.30.30.2

Maximum Link Bandwidth : 100000.00 kbits/sec

Reservable Bandwidth : 100000.00 kbits/sec

Unreserved Bandwidth:

Unreserved Bandwidth at priority 0: 100000.00 kbits/sec

```
Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 60
Metric: 10      IP-Extended 1.1.1.1/32
Metric: 20      IP-Extended 10.10.10.0/24
Metric: 15      IP-Extended 20.20.20.0/24
Metric: 60      IP-Extended 30.30.30.0/24
PE1.02-00      * 0x00000005  0x8047      902      0/0/0
Metric: 0      IS-Extended PE1.00
Metric: 0      IS-Extended P1.00
P1.00-00      0x0000000C  0xBA5B      1030      0/0/0
Area Address: 49.0001
NLPID: 0xCC
Hostname: P1
IP Address: 2.2.2.2
Router ID: 10.12.49.173
Metric: 10      IS-Extended PE1.02
IPv4 Interface Address: 10.10.10.2
Neighbor IP Address: 10.10.10.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10      IS-Extended P1.03
IPv4 Interface Address: 40.40.40.1
Neighbor IP Address: 40.40.40.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
```

```

TE-Default Metric: 10
Metric: 10      IP-Extended 2.2.2.2/32
Metric: 10      IP-Extended 10.10.10.0/24
Metric: 10      IP-Extended 40.40.40.0/24
P1.03-00      0x00000005  0xB60B      990      0/0/0
Metric: 0      IS-Extended P1.00
Metric: 0      IS-Extended PE2.00
P2.00-00      0x0000000B  0xFA56      1034     0/0/0
Area Address: 49.0001
NLPID: 0xCC
Hostname: P2
IP Address: 3.3.3.3
Router ID: 10.12.49.176
Metric: 10      IS-Extended P2.02
IPv4 Interface Address: 20.20.20.2
Neighbor IP Address: 20.20.20.2
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10      IS-Extended P2.03
IPv4 Interface Address: 50.50.50.1
Neighbor IP Address: 50.50.50.1
Maximum Link Bandwidth : 100000.00 kbits/sec
Reservable Bandwidth : 100000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
TE-Default Metric: 10
Metric: 10      IP-Extended 3.3.3.3/32
Metric: 10      IP-Extended 50.50.50.0/24
Metric: 10      IP-Extended 20.20.20.0/24
P2.02-00      0x00000005  0x6E56      926      0/0/0
Metric: 0      IS-Extended P2.00
Metric: 0      IS-Extended PE1.00
P2.03-00      0x00000005  0xB708      1020     0/0/0

```

```

Metric:    0          IS-Extended P2.00
Metric:    0          IS-Extended PE2.00
P3.00-00    0x0000000B  0xD9B2          1055          0/0/0
Area Address: 49.0001
NLPID:      0xCC
Hostname:    P3
IP Address:  4.4.4.4
Router ID:   10.12.49.177
Metric:    10          IS-Extended P3.02
  IPv4 Interface Address: 30.30.30.2
  Neighbor IP Address: 30.30.30.2
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 10
Metric:    10          IS-Extended PE2.04
  IPv4 Interface Address: 60.60.60.1
  Neighbor IP Address: 60.60.60.2
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 10
Metric:    10          IP-Extended 4.4.4.4/32
Metric:    10          IP-Extended 60.60.60.0/24
Metric:    10          IP-Extended 30.30.30.0/24
P3.02-00    0x00000005  0x6F53          941          0/0/0
  Metric:    0          IS-Extended P3.00
  Metric:    0          IS-Extended PE1.00
PE2.00-00    0x0000000E  0xDB03          1051          0/0/0
Area Address: 49.0001
NLPID:      0xCC
Hostname:    PE2
IP Address:  5.5.5.5
Router ID:   10.12.49.174

```

```
Metric: 10          IS-Extended P1.03
  IPv4 Interface Address: 40.40.40.2
  Neighbor IP Address: 40.40.40.1
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 10
Metric: 10          IS-Extended P2.03
  IPv4 Interface Address: 50.50.50.2
  Neighbor IP Address: 50.50.50.1
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 10
Metric: 10          IS-Extended PE2.04
  IPv4 Interface Address: 60.60.60.2
  Neighbor IP Address: 60.60.60.2
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 10
Metric: 10          IP-Extended 5.5.5.5/32
Metric: 10          IP-Extended 60.60.60.0/24
Metric: 10          IP-Extended 50.50.50.0/24
Metric: 10          IP-Extended 40.40.40.0/24
PE2.04-00          0x00000005    0x9E1D          1050          0/0/0
```

Metric: 0 IS-Extended PE2.00
 Metric: 0 IS-Extended P3.00

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
5.5.5.5	xe3	Passive	OPERATIONAL	30	01:02:53
2.2.2.2	xe1	Passive	OPERATIONAL	30	01:04:55
3.3.3.3	xe2	Passive	OPERATIONAL	30	01:04:07
4.4.4.4	xe3	Passive	OPERATIONAL	30	01:04:14

PE1#show ldp routes

Prefix Addr	Nexthop Addr	Intf	Backup Addr	Backup Intf	Owner
0.0.0.0/0	10.12.49.1	xe0	-	-	kernel
1.1.1.1/32	0.0.0.0	lo	-	-	connected
2.2.2.2/32	10.10.10.2	xe1	-	-	isis
3.3.3.3/32	20.20.20.2	xe2	-	-	isis
4.4.4.4/32	20.20.20.2	xe2	-	-	isis
5.5.5.5/32	20.20.20.2	xe2	-	-	isis
10.10.10.0/24	0.0.0.0	xe1	-	-	connected
10.12.49.0/24	0.0.0.0	xe0	-	-	connected
20.20.20.0/24	0.0.0.0	xe2	-	-	connected
30.30.30.0/24	0.0.0.0	xe3	-	-	connected
40.40.40.0/24	10.10.10.2	xe1	30.30.30.2	xe3	isis
50.50.50.0/24	20.20.20.2	xe2	-	-	isis
60.60.60.0/24	20.20.20.2	xe2	-	-	isis

PE1#show ip route

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
 O - OSPF, IA - OSPF inter area
 N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
 E1 - OSPF external type 1, E2 - OSPF external type 2
 i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
 ia - IS-IS inter area, E - EVPN,
 v - vrf leaked
 * - candidate default

IP Route Table for VRF "default"

Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*	0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C	1.1.1.1/32 is directly connected, lo, 01:13:04
i L1	2.2.2.2/32 [115/30] via 10.10.10.2, xe1, 01:05:05
i L1	3.3.3.3/32 [115/25] via 20.20.20.2, xe2, 01:03:35
i L1	4.4.4.4/32 [115/45] via 20.20.20.2, xe2, 01:01:55
i L1	5.5.5.5/32 [115/35] via 20.20.20.2, xe2, 01:02:45
C	10.10.10.0/24 is directly connected, xe1, 01:13:04
C	10.12.49.0/24 is directly connected, xe0, 01:17:43
C	20.20.20.0/24 is directly connected, xe2, 01:13:04
C	30.30.30.0/24 is directly connected, xe3, 01:13:04
i L1	40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 01:02:45

```
i L1          50.50.50.0/24 [115/25] via 20.20.20.2, xe2, 01:02:45
i L1          60.60.60.0/24 [115/35] via 20.20.20.2, xe2, 01:02:45
C             127.0.0.0/8 is directly connected, lo, 03:48:54
```

```
PE1#show ip route summary
```

```
-----
IP routing table name is Default-IP-Routing-Table(0)
-----
```

```
IP routing table maximum-paths    : 8
Total number of IPv4 routes       : 14
Total number of IPv4 paths        : 14
Pending routes (due to route max reached): 0
Route Source    Networks
kernel          1
connected       6
isis            7
Total           14
FIB             14
```

```
ECMP statistics (active in ASIC):
```

```
Total number of IPv4 ECMP routes : 0
Total number of IPv4 ECMP paths  : 0
```

```
LFA Non ECMP statistics
```

```
-----
Total number of Routes           : 1
Total number of Primary Paths    : 1
Total number of Backup Paths     : 1
```

```
PE1#show ip interface brief
```

```
'*' - address is assigned by dhcp client
```

Interface	IP-Address	Admin-Status	Link-Status
xe0	*10.12.49.172	up	up
xe1	unassigned	up	up
xe1	10.10.10.1	up	up
xe3	unassigned	up	up
xe4	unassigned	up	up
xe5	unassigned	up	up
xe6	unassigned	up	up
xe7	unassigned	up	up
xe8	unassigned	up	up
xe9	unassigned	up	up
xe10	unassigned	up	up
xe11	unassigned	up	up
xe2	20.20.20.1	up	up
xe3	30.30.30.1	up	up
lo	127.0.0.1	up	up

```
PE1#show ip isis route fast-reroute
```

```
Tag : 1 VRF : default
```

```
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        D - discard, LP - Link Protecting, NP - Node Protecting,
        BP - Broadcast Interface Disjoint, Pri - Primary Path,
        Sec - Secondary Path, DP - Downstream Path
```

```
L1 40.40.40.0/24
```

```
Primary Path via : 10.10.10.2, xe1
```

```
FRR Backup Path via : 30.30.30.2, xe3
```

```
FRR Metric : 80
```

```
Protection Provided : LP NP BP DP
```

```
PE1#show ldp routes
```

Prefix Addr	Nexthop Addr	Intf	Backup Addr	Backup Intf	Owner
0.0.0.0/0	10.12.49.1	xe0	-	-	kernel
1.1.1.1/32	0.0.0.0	lo	-	-	connected
2.2.2.2/32	10.10.10.2	xe1	-	-	isis
3.3.3.3/32	20.20.20.2	xe2	-	-	isis
4.4.4.4/32	20.20.20.2	xe2	-	-	isis
5.5.5.5/32	20.20.20.2	xe2	-	-	isis
10.10.10.0/24	0.0.0.0	xe1	-	-	connected
10.12.49.0/24	0.0.0.0	xe0	-	-	connected
20.20.20.0/24	0.0.0.0	xe2	-	-	connected
30.30.30.0/24	0.0.0.0	xe3	-	-	connected
40.40.40.0/24	10.10.10.2	xe1	30.30.30.2	xe3	isis
50.50.50.0/24	20.20.20.2	xe2	-	-	isis
60.60.60.0/24	20.20.20.2	xe2	-	-	isis

```
PE1#show ldp fec
```

```
LSR codes : E/N - LSR is egress/non-egress for this FEC,
            L - LSR received a label for this FEC,
            P - Primary route, B - LFA Backup route,
            R - Remote LFA Backup route,
            > - LSR will use this route for the FEC
```

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	E >	non-existent	none	No	connected
2.2.2.2/32	NL	4.4.4.4	25608	No	no nexthop
	NL	3.3.3.3	25608	No	no nexthop
	NLP>	2.2.2.2	impl-null	No	10.10.10.2
3.3.3.3/32	NL	2.2.2.2	25608	No	no nexthop
	NL	4.4.4.4	25609	No	no nexthop
	NLP>	3.3.3.3	impl-null	No	20.20.20.2
4.4.4.4/32	NL	2.2.2.2	25609	No	no nexthop
	NLP>	3.3.3.3	25609	No	20.20.20.2
	NL	4.4.4.4	impl-null	No	no nexthop
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NLP>	3.3.3.3	25610	No	20.20.20.2

10.10.10.0/24	NL	2.2.2.2	25600	No	no nexthop
	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
10.12.49.0/24	NL	3.3.3.3	impl-null	No	connected
	NL	4.4.4.4	impl-null	No	connected
	NL	2.2.2.2	impl-null	No	connected
20.20.20.0/24	E >	non-existent	none	No	connected
	NL	3.3.3.3	impl-null	No	connected
	E >	non-existent	none	No	connected
30.30.30.0/24	NL	2.2.2.2	25610	No	connected
	NL	3.3.3.3	25611	No	connected
	NL	4.4.4.4	impl-null	No	connected
40.40.40.0/24	E >	non-existent	none	No	connected
	NLB>	4.4.4.4	25611	No	30.30.30.2
	NL	3.3.3.3	25612	No	no nexthop
50.50.50.0/24	NLP>	2.2.2.2	impl-null	No	10.10.10.2
	NL	2.2.2.2	25611	No	no nexthop
	NL	4.4.4.4	25612	No	no nexthop
60.60.60.0/24	NLP>	3.3.3.3	impl-null	No	20.20.20.2
	NL	2.2.2.2	25612	No	no nexthop
	NLP>	3.3.3.3	25613	No	20.20.20.2
	NL	4.4.4.4	impl-null	No	no nexthop

PE1#show ldp downstream

Codes: P - Primary route, B - Backup route

Session peer 5.5.5.5:

FEC Code	Nexthop	Addr	State	Label	Req.ID	Attr
----------	---------	------	-------	-------	--------	------

Codes: P - Primary route, B - Backup route

Session peer 2.2.2.2:

FEC Code	Nexthop	Addr	State	Label	Req.ID	Attr
----------	---------	------	-------	-------	--------	------

60.60.60.0/24	connected		Established		25612	0
50.50.50.0/24	connected		Established		25611	0
30.30.30.0/24	connected		Established		25610	0
4.4.4.4/32	connected		Established		25609	0
3.3.3.3/32	connected		Established		25608	0
5.5.5.5/32	connected		Established		25600	0
40.40.40.0/24	10.10.10.2		Established	impl-null	0	
P 10.12.49.0/24	connected		Established	impl-null		0
10.10.10.0/24	connected		Established	impl-null		0
2.2.2.2/32	10.10.10.2		Established	impl-null	0	

P

Codes: P - Primary route, B - Backup route

Session peer 3.3.3.3:

FEC Code	Nexthop	Addr	State	Label	Req.ID	Attr
----------	---------	------	-------	-------	--------	------

40.40.40.0/24	connected		Established		25612	0
30.30.30.0/24	connected		Established		25611	0
4.4.4.4/32	20.20.20.2		Established	25609	0	
P 2.2.2.2/32	connected		Established		25608	0

P	60.60.60.0/24	20.20.20.2	Established	25613	0
P	5.5.5.5/32	20.20.20.2	Established	25610	0
P	50.50.50.0/24	20.20.20.2	Established	impl-null	0
	20.20.20.0/24	connected	Established	impl-null	0
	10.12.49.0/24	connected	Established	impl-null	0
P	3.3.3.3/32	20.20.20.2	Established	impl-null	0

Codes: P - Primary route, B - Backup route

Session peer 4.4.4.4:

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
50.50.50.0/24	connected	Established	25612	0	
40.40.40.0/24	connected	Established	25611	0	
B 40.40.40.0/24	30.30.30.2	Established	25611	0	
5.5.5.5/32	connected	Established	25610	0	
3.3.3.3/32	connected	Established	25609	0	
2.2.2.2/32	connected	Established	25608	0	
60.60.60.0/24	connected	Established	impl-null	0	
30.30.30.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
4.4.4.4/32	connected	Established	impl-null	0	

PE1#show ldp lsp

DOWNSTREAM LSP :

FEC Code	Nexthop Addr	State	Label	Req.ID	Attr
1.1.1.1/32	connected	Established	none	0	None
2.2.2.2/32	connected	Established	25608	0	
2.2.2.2/32	connected	Established	25608	0	
P 2.2.2.2/32	10.10.10.2	Established	impl-null	0	
3.3.3.3/32	connected	Established	25608	0	
3.3.3.3/32	connected	Established	25609	0	
P 3.3.3.3/32	20.20.20.2	Established	impl-null	0	
4.4.4.4/32	connected	Established	25609	0	
P 4.4.4.4/32	20.20.20.2	Established	25609	0	
4.4.4.4/32	connected	Established	impl-null	0	
5.5.5.5/32	connected	Established	25610	0	
P 5.5.5.5/32	20.20.20.2	Established	25610	0	
5.5.5.5/32	connected	Established	25600	0	
10.10.10.0/24	connected	Established	impl-null	0	
10.10.10.0/24	connected	Established	none	0	None
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	impl-null	0	
10.12.49.0/24	connected	Established	none	0	None

	20.20.20.0/24	connected	Established	impl-null	0	
	20.20.20.0/24	connected	Established	none	0	None
	30.30.30.0/24	connected	Established	25610	0	
	30.30.30.0/24	connected	Established	25611	0	
	30.30.30.0/24	connected	Established	impl-null	0	
	30.30.30.0/24	connected	Established	none	0	None
	40.40.40.0/24	connected	Established	25611	0	
B	40.40.40.0/24	30.30.30.2	Established	25611	0	
	40.40.40.0/24	connected	Established	25612	0	
P	40.40.40.0/24	10.10.10.2	Established	impl-null	0	
	50.50.50.0/24	connected	Established	25611	0	
	50.50.50.0/24	connected	Established	25612	0	
P	50.50.50.0/24	20.20.20.2	Established	impl-null	0	
	60.60.60.0/24	connected	Established	25612	0	
P	60.60.60.0/24	20.20.20.2	Established	25613	0	
	60.60.60.0/24	connected	Established	impl-null	0	

UPSTREAM LSP :

FEC	State	Label	Req.ID	Attr
1.1.1.1/32	Established	impl-null	0	None
1.1.1.1/32	Established	impl-null	0	None
1.1.1.1/32	Established	impl-null	0	None
2.2.2.2/32	Established	25608	0	None
2.2.2.2/32	Established	25604	0	None
2.2.2.2/32	Established	25604	0	None
2.2.2.2/32	Established	25608	0	None
3.3.3.3/32	Established	25605	0	None
3.3.3.3/32	Established	25600	0	None
3.3.3.3/32	Established	25605	0	None
3.3.3.3/32	Established	25600	0	None
4.4.4.4/32	Established	25603	0	None
4.4.4.4/32	Established	25602	0	None
4.4.4.4/32	Established	25603	0	None
4.4.4.4/32	Established	25602	0	None
5.5.5.5/32	Established	25614	0	None
5.5.5.5/32	Established	25614	0	None
5.5.5.5/32	Established	25615	0	None
5.5.5.5/32	Established	25615	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.10.10.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
10.12.49.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None
20.20.20.0/24	Established	impl-null	0	None

30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
30.30.30.0/24	Established	impl-null	0	None
40.40.40.0/24	Established	25610	0	None
40.40.40.0/24	Established	25606	0	None
40.40.40.0/24	Established	25606	0	None
40.40.40.0/24	Established	25610	0	None
50.50.50.0/24	Established	25607	0	None
50.50.50.0/24	Established	25601	0	None
50.50.50.0/24	Established	25607	0	None
50.50.50.0/24	Established	25601	0	None
60.60.60.0/24	Established	25616	0	None
60.60.60.0/24	Established	25616	0	None
60.60.60.0/24	Established	25617	0	None
60.60.60.0/24	Established	25617	0	None

PE1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2					
L>	3.3.3.3/32	5	3	-	Yes	LSP_DEFAULT	3
xe2	No	20.20.20.2					
L>	4.4.4.4/32	3	7	-	Yes	LSP_DEFAULT	25609
xe2	No	20.20.20.2					
L>	5.5.5.5/32	7	5	-	Yes	LSP_DEFAULT	25610
xe2	No	20.20.20.2					
L>	40.40.40.0/24	2	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2					
			15	-	No	LSP_DEFAULT	25611
xe3	No	30.30.30.2					
L>	50.50.50.0/24	6	3	-	Yes	LSP_DEFAULT	3
xe2	No	20.20.20.2					
L>	60.60.60.0/24	4	6	-	Yes	LSP_DEFAULT	25613
xe2	No	20.20.20.2					

PE1#show mpls forwarding-table 5.5.5.5/32

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	5.5.5.5/32	7	5	-	Yes	LSP_DEFAULT	25610
xe2	No	20.20.20.2					

PE1#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609

Nexthop addr: 20.20.20.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610

Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 15

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 15, owner: LDP, Stale: NO, out intf: xe3, out label: 25611

Nexthop addr: 30.30.30.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613

Nexthop addr: 20.20.20.2 cross connect ix: 6, op code: Push

PE1#show mpls ftn-table 5.5.5.5/32

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610

Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

PE1#show ldp fec prefix 5.5.5.5/32

LSR codes : E/N - LSR is egress/non-egress for this FEC,

 L - LSR received a label for this FEC,

 P - Primary route, B - LFA Backup route,

 R - Remote LFA Backup route,

 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
-----	------	---------	-----------	-----	--------------

```

5.5.5.5/32      NL      4.4.4.4      25610      No      no nexthop
                NLP>    3.3.3.3      25610      No      20.20.20.2
                NL      2.2.2.2      25600      No      no nexthop

```

PE1#show ip route fast-reroute

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP

O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2

i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area ,p - stale info, E - EVPN

* - candidate default

IP Route Table for VRF "default"

```

i L1    40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 01:04:31
        [FRR-NH] via 30.30.30.2, xe3

```

PE1#show ip isis route fast-reroute

Tag : 1 VRF : default

Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,

D - discard, LP - Link Protecting, NP - Node Protecting,

BP - Broadcast Interface Disjoint, Pri - Primary Path,

Sec - Secondary Path, DP - Downstream Path

L1 40.40.40.0/24

Primary Path via : 10.10.10.2, xe1

FRR Backup Path via : 30.30.30.2, xe3

FRR Metric : 80

Protection Provided : LP NP BP DP

PE1#show ldp routes

Prefix Addr	Nexthop Addr	Intf	Backup Addr	Backup Intf	Owner
0.0.0.0/0	10.12.49.1	xe0	-	-	kernel
1.1.1.1/32	0.0.0.0	lo	-	-	connected
2.2.2.2/32	10.10.10.2	xe1	-	-	isis
3.3.3.3/32	20.20.20.2	xe2	-	-	isis
4.4.4.4/32	20.20.20.2	xe2	-	-	isis
5.5.5.5/32	20.20.20.2	xe2	-	-	isis
10.10.10.0/24	0.0.0.0	xe1	-	-	connected
10.12.49.0/24	0.0.0.0	xe0	-	-	connected
20.20.20.0/24	0.0.0.0	xe2	-	-	connected
30.30.30.0/24	0.0.0.0	xe3	-	-	connected
40.40.40.0/24	10.10.10.2	xe1	30.30.30.2	xe3	isis
50.50.50.0/24	20.20.20.2	xe2	-	-	isis
60.60.60.0/24	20.20.20.2	xe2	-	-	isis

PE1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2					
L>	3.3.3.3/32	5	3	-	Yes	LSP_DEFAULT	3
xe2	No	20.20.20.2					
L>	4.4.4.4/32	3	7	-	Yes	LSP_DEFAULT	25609
xe2	No	20.20.20.2					
L>	5.5.5.5/32	7	5	-	Yes	LSP_DEFAULT	25610
xe2	No	20.20.20.2					
L>	40.40.40.0/24	2	1	-	Yes	LSP_DEFAULT	3
xe1	No	10.10.10.2					
			15	-	No	LSP_DEFAULT	25611
xe3	No	30.30.30.2					
L>	50.50.50.0/24	6	3	-	Yes	LSP_DEFAULT	3
xe2	No	20.20.20.2					
L>	60.60.60.0/24	4	6	-	Yes	LSP_DEFAULT	25613
xe2	No	20.20.20.2					

PE1#show mpls forwarding-table 5.5.5.5/32

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	5.5.5.5/32	7	5	-	Yes	LSP_DEFAULT	25610
xe2	No	20.20.20.2					

PE1#show mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
Nexthop addr: 20.20.20.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 10.10.10.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 15
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 15, owner: LDP, Stale: NO, out intf: xe3, out label: 25611
Nexthop addr: 30.30.30.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 20.20.20.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613

Nexthop addr: 20.20.20.2 cross connect ix: 6, op code: Push

PE1#show mpls ftn-table 5.5.5.5/32

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0

Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610

Nexthop addr: 20.20.20.2 cross connect ix: 5, op code: Push

PE1#show ldp fec prefix 5.5.5.5/32

LSR codes : E/N - LSR is egress/non-egress for this FEC,

L - LSR received a label for this FEC,

P - Primary route, B - LFA Backup route,

R - Remote LFA Backup route,

> - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
5.5.5.5/32	NL	4.4.4.4	25610	No	no nexthop
	NLP>	3.3.3.3	25610	No	20.20.20.2
	NL	2.2.2.2	25600	No	

CHAPTER 5 TCP MSS configuration for LDP sessions

Overview

Label Distribution Protocol (LDP) uses Transmission Control Protocol (TCP) to establish sessions between the devices. This feature enables the configuration of TCP Maximum Segment Size (MSS) that defines the maximum segment size in a single TCP segment during a communication session. TCP segment is a unit of data transmitted in a TCP connection. TCP uses three-way handshake process for initial establishment of a TCP connection. In the three-way handshake process, the sending host sends a SYN packet. Once the receiving host receives the SYN packet, it acknowledges and sends back a SYN-ACK packet to the sending host. Once the sending host receives the SYN-ACK packet from the receiving host, it sends an ACK packet, establishing a reliable connection. In this three way handshake process, the MSS is negotiated between the LDP neighbors.

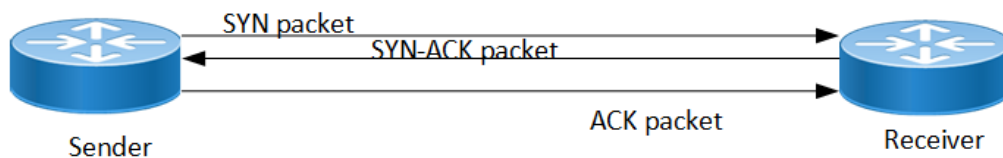


Figure 5-4: Three-way handshake

Feature Characteristics

The configuration of the TCP MSS for LDP neighbors helps the neighbors adjust the MSS value of the TCP SYN packet. Configure the TCP MSS through the CLI and NetConf interface. The configurable MSS range is offered from 560 to 1440. By default, the MTU value for ethernet cable is 1500 bytes. When configuring the highest MSS value that is 1440, the total MSS becomes 1440 bytes (MSS) plus 20 bytes (IP Header Size), 20 bytes (TCP Header), and Ethernet header which does not cross the default path MTU value.

Note: After configuring TCP MSS, use `clear ldp session` command to apply the MSS for the operational session.



Configuring TCP MSS

Benefits

By default, the interface MTU value determines the MSS value of an LDP packet. When the interface MTU value exceeds the default ethernet path MTU value of 1500 bytes, the MSS value also crosses the default ethernet path MTU

value, resulting in packet fragmentation. The configuration of the specific MSS value limits the packet size irrespective of the interface MTU value, preventing packet fragmentation.[

Prerequisites

Requires the knowledge on TCP handshake and the formation of LDP neighbors.

Configuration

This section shows the procedure to configure TCP MSS for LDP session.

Enable Label Switching

Running LDP on a system requires the following tasks:

- 1. Enabling label-switching on the interface on NSM.
- 2. Enabling LDP on an interface in the LDP daemon.
- 3. Running an Internal Gateway Protocol (IGP), for example, Open Shortest Path first (OSPF), to distribute reachability information within the MPLS cloud.
- 4. Configuring the transport address.
- 5. Configure the TCP MSS neighbor on peer node (Active node).

Topology

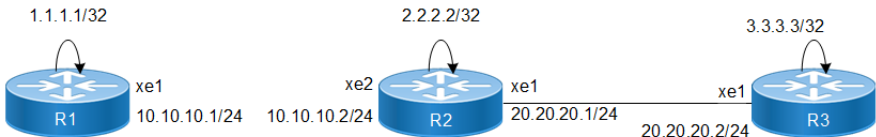


Figure 5-5: Device topology for TCP MSS for LDP

Configuration

The below configuration shows how to configure the TCP MSS value for the LDP neighbors.

R1 - NSM

R1#configure terminal	Enter configure mode.
R1(config)#interface xe1	Specify the interface xe1 to be configured.
R1(config-if)#ip address 10.10.10.1/24	Assign IP address 10.10.10.1/24 to interface.
R1(config-if)#label-switching	Enable label switching on interface xe1.
R1(config-if)#exit	Exit interface mode.

R1(config)#interface lo	Specify the loopback interface to be configured.
R1(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
R1(config-if)#commit	Commit the transaction.

R1 - LDP

R1(config)#router ldp	Enter Router mode for LDP.
R1(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1.
R1(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter <code>ipv6</code> if you are configuring an IPv6 interface.
R1(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted peer 3.3.3.3.
R1(config-router-targeted-peer)#exit	Exit targeted peer-mode.
R1(config-router)#exit	Exit the router mode and return to the configure mode.
R1(config)#interface xe1	Enter interface mode xe1.
R1(config-if)#enable-ldp ipv4	Enable LDP on xe1.
R1(config-if)#commit	Commit the transaction.

R1 - OSPF

R1(config)#router ospf 100	Configure the routing process and specify the process ID 100. The process ID should be a unique positive integer identifying the routing process.
R1(config-router)#network 10.10.10.0/24 area 0	Define the interface 10.10.10.0/24, on which OSPF runs and associate the area ID 0 with the interface.
R1(config-router)#network 1.1.1.1/32 area 0	Define the interface 1.1.1.1/32, on which OSPF runs and associate the area ID 0 with the interface.
R1(config-router)#commit	Commit the transaction.

R2 - NSM

R2#configure terminal	Enter configure mode.
R2(config)#interface lo	Specify the loopback interface to be configured.
R2(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe1	Specify the interface xe1 to be configured.
R2(config-if)#ip address 20.20.20.1/24	Assign IP address 20.20.20.1/24 to interface.
R2(config-if)#label-switching	Enable label switching on interface xe1.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe2	Specify the interface xe2 to be configured.

R2(config-if)#ip address 10.10.10.2/24	Assign IP address 10.10.10.2/24 to interface.
R2(config-if)#label-switching	Enable label switching on interface xe2.
R2(config-if)#commit	Commit the transaction.

R2 - LDP

R2(config)#router ldp	Enter Router mode.
R2(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.
R2(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter <code>ipv6</code> if you are configuring an IPv6 interface.
R2(config-router)#neighbor 1.1.1.1 tcp-mss 600	Configure the TCP MSS value on peer node which have active side only.
R2(config-router)#exit	Exit router mode and return to configure mode.
R2(config)#interface xe1	Specify the interface xe1 to be configured.
R2(config-if)#enable-ldp ipv4	Enable LDP on a specified interface xe1.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe2	Specify the interface xe2 to be configured.
R2(config-if)#enable-ldp ipv4	Enable LDP on a specified interface xe2.
R2(config-if)#commit	Commit the transaction.

R2 - OSPF

R2(config)#router ospf 100	Configure the routing process and specify the process ID 100. The process ID should be a unique positive integer identifying the routing process.
R2(config-router)#network 10.10.10.0/24 area 0	Define the interfaces 10.10.10.0/24, on which OSPF runs and associate the area ID 0 with them.
R2(config-router)#network 20.20.20.0/24 area 0	Define the interfaces 20.20.20.0/24, on which OSPF runs and associate the area ID 0 with them.
R2(config-router)#network 2.2.2.2/32 area 0	Define the interfaces 2.2.2.2/32, on which OSPF runs and associate the area ID 0 with them.
R2(config-router)#commit	Commit the transaction.

R3 - NSM

R3#configure terminal	Enter configure mode.
R3(config)#interface lo	Specify the loopback interface to be configured.
R3(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32.
R3(config-if)#exit	Exit interface mode.
R3(config)#interface xe1	Specify the interface xe1 to be configured.

R3(config-if)#ip address 20.20.20.2/24	Set the IP address of the interface to 20.20.20.2/24.
R3(config-if)#label-switching	Enable label switching on interface xe1.
R3(config-if)#commit	Commit the transaction.

R3 - LDP

R3(config)#router ldp	Enter Router mode.
R3(config-router)#router-id 3.3.3.3	Set the router ID for IP address 3.3.3.3.
R3(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter <code>ipv6</code> if you are configuring an IPv6 interface.
R3(config-router)#neighbor 2.2.2.2 tcp-mss 650	Configure the TCP MSS value on peer node which have active side only.
R3(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
R3(config-router-targeted-peer)#exit	Exit targeted peer-mode.
R3(config-router)#exit	Exit the router mode and return to the configure mode.
R3(config)#interface xe1	Enter interface mode xe1.
R3(config-if)#enable-ldp ipv4	Enable LDP on xe1.
R3(config-if)#commit	Commit the transaction.

R3 - OSPF

R3(config)#router ospf 100	Configure the routing process and specify the Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
R3(config-router)#network 20.20.20.0/24 area 0	Define the interfaces 20.20.20.0/24, on which OSPF runs and associate the area ID 0 with them.
R3(config-router)#network 3.3.3.3/32 area 0	Define the interfaces 3.3.3.3/32, on which OSPF runs and associate the area ID 0 with them.
R3(config-router)#commit	Commit the transaction.

Validation

R3

R3#show ldp session

Codes: m - MD5 password is not set/unset.
g - GR configuration not set/unset.
t - TCP MSS not set/unset.
Session has to be cleared manually

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	2.2.2.2	xe1	Active	OPERATIONAL	30	00:03:06

```

1.1.1.1          xe1          Active    OPERATIONAL    30    00:03:06

```

```

R3#show ldp targeted-peer count

```

```

-----
Num Targeted Peers: 1          [UP: 1]
-----

```

```

PE2#show ldp session count

```

```

-----
Multicast Peers      : 1          [UP: 1]
Targeted Peers      : 1          [UP: 1]
Total Sessions      : 2          [UP: 2]
-----

```

```

R3#show ldp routes

```

Prefix Addr	Nexthop Addr	Intf	Owner
1.1.1.1/32	20.20.20.1	xe1	ospf
2.2.2.2/32	20.20.20.1	xe1	ospf
3.3.3.3/32	0.0.0.0	lo	connected
10.10.10.0/24	20.20.20.1	xe1	ospf
20.20.20.0/24	0.0.0.0	xe1	connected

```

R3#show ldp fec-ipv4 count

```

```

-----
Num. IPv4 FEC(s): 5
-----

```

```

R3#show ldp session 2.2.2.2

```

```

Session state          : OPERATIONAL
Session role           : Active
TCP Connection          : Established
IP Address for TCP      : 2.2.2.2
Interface being used    : xe1
Peer LDP ID             : 2.2.2.2:0
Preferred Peer LDP Password : Not Set
Adjacencies            : 20.20.20.1
Advertisement mode      : Downstream Unsolicited
Label retention mode    : Liberal
Graceful Restart        : Not Capable
Keepalive Timeout       : 30
Reconnect Interval      : 15
Configured TCP MSS      : 650
Applied TCP MSS         : 650
Preferred TCP MSS       : NA
Address List received   : 2.2.2.2
                        10.10.10.2
                        20.20.20.1

```

Received Labels :	Fec	Label	Maps To
	IPV4:20.20.20.0/24	impl-null	none
	IPV4:10.10.10.0/24	impl-null	none
	IPV4:2.2.2.2/32	impl-null	none
	IPV4:1.1.1.1/32	25600	none
Sent Labels :	Fec	Label	Maps To
	IPV4:20.20.20.0/24	impl-null	none
	IPV4:3.3.3.3/32	impl-null	none

R2

```
R2#show ldp session
```

```
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
```

```
Session has to be cleared manually
```

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	3.3.3.3	xe1	Passive	OPERATIONAL	30	00:06:10
	1.1.1.1	xe2	Active	OPERATIONAL	30	00:06:10

```
R2#show ldp session count
```

```
-----
Multicast Peers      : 2          [UP: 2]
Targeted Peers      : 0          [UP: 0]
Total Sessions      : 2          [UP: 2]
-----
```

```
R2#show ldp routes
```

Prefix Addr	Nexthop Addr	Intf	Owner
1.1.1.1/32	10.10.10.1	xe2	ospf
2.2.2.2/32	0.0.0.0	lo	connected
3.3.3.3/32	20.20.20.2	xe1	ospf
10.10.10.0/24	0.0.0.0	xe2	connected
20.20.20.0/24	0.0.0.0	xe1	connected

```
R2#show ldp session 1.1.1.1
```

```
Session state          : OPERATIONAL
Session role           : Active
TCP Connection         : Established
IP Address for TCP     : 1.1.1.1
Interface being used   : xe2
Peer LDP ID            : 1.1.1.1:0
Preferred Peer LDP Password : Not Set
Adjacencies           : 10.10.10.1
Advertisement mode     : Downstream Unsolicited
Label retention mode   : Liberal
Graceful Restart      : Not Capable
Keepalive Timeout      : 30
Reconnect Interval     : 15
Configured TCP MSS     : 600
Applied TCP MSS        : 600
Preferred TCP MSS      : NA
Address List received  : 1.1.1.1
                       10.10.10.1
                       48.48.48.48
```

Received Labels :	Fec	Label	Maps To
	IPV4:10.10.10.0/24	impl-null	none
	IPV4:1.1.1.1/32	impl-null	25600
Sent Labels :	Fec	Label	Maps To
	IPV4:20.20.20.0/24	impl-null	none
	IPV4:10.10.10.0/24	impl-null	none

IPV4:3.3.3.3/32	25601	impl-null
IPV4:2.2.2.2/32	impl-null	none

R1

R1#show ldp session

Codes: m - MD5 password is not set/unset.
 g - GR configuration not set/unset.
 t - TCP MSS not set/unset.
 Session has to be cleared manually

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	2.2.2.2	xe1	Passive	OPERATIONAL	30	00:07:12
	3.3.3.3	xe1	Passive	OPERATIONAL	30	00:07:12

R1#show ldp session count

```
-----
Multicast Peers      : 1          [UP: 1]
Targeted Peers      : 1          [UP: 1]
Total Sessions      : 2          [UP: 2]
-----
```

R1#show ldp targeted-peer count

```
-----
Num Targeted Peers: 1          [UP: 1]
-----
```

R1#show ldp routes

Prefix Addr	Nexthop Addr	Intf	Owner
1.1.1.1/32	0.0.0.0	lo	connected
2.2.2.2/32	10.10.10.2	xe1	ospf
3.3.3.3/32	10.10.10.2	xe1	ospf
10.10.10.0/24	0.0.0.0	xe1	connected
20.20.20.0/24	10.10.10.2	xe1	ospf

R1#show ldp fec

LSR codes : E/N - LSR is egress/non-egress for this FEC,
 L - LSR received a label for this FEC,
 > - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
1.1.1.1/32	E >	non-existent	none	No	connected
2.2.2.2/32	NL>	2.2.2.2	impl-null	No	10.10.10.2
3.3.3.3/32	NL>	2.2.2.2	25601	No	10.10.10.2
10.10.10.0/24	NL	2.2.2.2	impl-null	No	connected
	E >	non-existent	none	No	connected
20.20.20.0/24	NL>	2.2.2.2	impl-null	No	10.10.10.2
48.48.48.48/32	E >	non-existent	none	No	connected

Configure TCP MSS on ALL neighbor

R1 - NSM

R1#configure terminal	Enter configure mode.
R1(config)#interface xe1	Specify the interface xe1 to be configured.
R1(config-if)#ip address 10.10.10.1/24	Assign IP address 10.10.10.1/24 to interface.
R1(config-if)#label-switching	Enable label switching on interface xe1.
R1(config-if)#exit	Exit interface mode.
R1(config)#interface lo	Specify the loopback interface to be configured.
R1(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
R1(config-if)#commit	Commit the transaction.

R1 - LDP

R1(config)#router ldp	Enter Router mode for LDP.
R1(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1.
R1(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter <code>ipv6</code> if you are configuring an IPv6 interface.
R1(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted peer.
R1(config-router)#neighbor all tcp-mss 700	Configure the TCP MSS value with all neighbor.
R1(config-router-targeted-peer)#exit	Exit-targeted-peer-mode.
R1(config-router)#exit	Exit the Router mode and return to the Configure mode.
R1(config)#interface xe1	Enter interface mode xe1.
R1(config-if)#enable-ldp ipv4	Enable LDP on xe1.
R1(config-if)#commit	Commit the transaction.

R1 - OSPF

R1(config)#router ospf 100	Configure the routing process and specify the process ID (100). The process ID should be a unique positive integer identifying the routing process.
R1(config-router)#network 10.10.10.0/24 area 0	Define the interface 10.10.10.0/24, on which OSPF runs and associate the area ID (0) with the interface.
R1(config-router)#network 1.1.1.1/32 area 0	Define the interface 1.1.1.1/32, on which OSPF runs and associate the area ID (0) with the interface.
R1(config-router)#commit	Commit the transaction.

R2 - NSM

R2#configure terminal	Enter configure mode.
R2(config)#interface lo	Specify the loopback (lo) interface to be configured.
R2(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe1	Specify the interface xe1 to be configured.
R2(config-if)#ip address 20.20.20.1/24	Assign IP address 20.20.20.1/24 to interface.
R2(config-if)#label-switching	Enable label switching on interface xe1.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe2	Specify the interface xe2 to be configured.
R2(config-if)#ip address 10.10.10.2/24	Assign IP address 10.10.10.2/24 to interface.
R2(config-if)#label-switching	Enable label switching on interface xe2.
R2(config-if)#commit	Commit the transaction.

R2 - LDP

R2(config)#router ldp	Enter Router mode.
R2(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.
R2(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter <code>ipv6</code> if you are configuring an IPv6 interface.
R2(config-router)#neighbor all tcp-mss 710	Configure the TCP MSS value with all neighbor.
R2(config-router)#exit	Exit Router mode and return to configure mode.
R2(config)#interface xe1	Specify the interface xe1 to be configured.
R2(config-if)#enable-ldp ipv4	Enable LDP on a specified interface xe1.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe2	Specify the interface xe2 to be configured.
R2(config-if)#enable-ldp ipv4	Enable LDP on a specified interface xe2.
R2(config-if)#commit	Commit the transaction.

R2 - OSPF

R2(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
R2(config-router)#network 10.10.10.0/24 area 0	Define the interfaces 10.10.10.0/24, on which OSPF runs and associate the area ID (0) with them.
R2(config-router)#network 20.20.20.0/24 area 0	Define the interfaces 20.20.20.0/24, on which OSPF runs and associate the area ID (0) with them.

R2(config-router)#network 2.2.2.2/32 area 0	Define the interfaces 2.2.2.2/32, on which OSPF runs and associate the area ID (0) with them.
R2(config-router)#commit	Commit the transaction.

R3 - NSM

R3#configure terminal	Enter configure mode.
R3(config)#interface lo	Specify the loopback interface to be configured.
R3(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32.
R3(config-if)#exit	Exit interface mode.
R3(config)#interface xe1	Specify the interface xe1 to be configured.
R3(config-if)#ip address 20.20.20.2/24	Set the IP address of the interface to 20.20.20.2/24.
R3(config-if)#label-switching	Enable label switching on interface xe1.
R3(config-if)#commit	Commit the transaction.

R3 - LDP

R3(config)#router ldp	Enter Router mode.
R3(config-router)#router-id 3.3.3.3	Set the router ID for IP address 3.3.3.3.
R3(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter <code>ipv6</code> if you are configuring an IPv6 interface.
R3(config-router)#neighbor all tcp-mss 720	Configure the TCP MSS value with all neighbor.
R3(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
R3(config-router-targeted-peer)#exit	Exit-targeted-peer-mode.
R3(config-router)#exit	Exit the Router mode and return to the Configure mode.
R3(config)#interface xe1	Enter interface mode.
R3(config-if)#enable-ldp ipv4	Enable LDP on xe1.
R3(config-if)#commit	Commit the transaction.

R3 - OSPF

R3(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
R3(config-router)#network 20.20.20.0/24 area 0	Define the interfaces 20.20.20.0/24, on which OSPF runs and associate the area ID (0) with them.
R3(config-router)#network 3.3.3.3/32 area 0	Define the interfaces 3.3.3.3/32, on which OSPF runs and associate the area ID (0) with them.
R3(config-router)#commit	Commit the transaction.

Validation

R1

R1#show ldp session

Codes: m - MD5 password is not set/unset.
 g - GR configuration not set/unset.
 t - TCP MSS not set/unset.
 Session has to be cleared manually

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	2.2.2.2	xe1	Passive	OPERATIONAL	30	00:11:22
	3.3.3.3	xe1	Passive	OPERATIONAL	30	00:11:22

R1#show ldp session 2.2.2.2

```

Session state           : OPERATIONAL
Session role            : Passive
TCP Connection          : Established
IP Address for TCP      : 2.2.2.2
Interface being used    : xe1
Peer LDP ID             : 2.2.2.2:0
Preferred Peer LDP Password : Not Set
Adjacencies             : 10.10.10.2
Advertisement mode       : Downstream Unsolicited
Label retention mode     : Liberal
Graceful Restart        : Not Capable
Keepalive Timeout       : 30
Reconnect Interval      : 15
Configured TCP MSS      : 700
Applied TCP MSS         : 700
Preferred TCP MSS       : NA
Address List received    : 2.2.2.2
                        10.10.10.2
                        20.20.20.1
  
```

Received Labels :	Fec	Label	Maps To
	IPV4:20.20.20.0/24	impl-null	none
	IPV4:10.10.10.0/24	impl-null	none
	IPV4:3.3.3.3/32	25601	none
	IPV4:2.2.2.2/32	impl-null	none
Sent Labels :	Fec	Label	Maps To
	IPV4:10.10.10.0/24	impl-null	none
	IPV4:1.1.1.1/32	impl-null	none

R1#show ldp session 3.3.3.3

```

Session state           : OPERATIONAL
Session role            : Passive
TCP Connection          : Established
IP Address for TCP      : 3.3.3.3
Interface being used    : xe1
Peer LDP ID             : 3.3.3.3:0
Preferred Peer LDP Password : Not Set
Adjacencies             : 3.3.3.3
Advertisement mode       : Downstream Unsolicited
  
```

```

Label retention mode      : Liberal
Graceful Restart         : Not Capable
Keepalive Timeout        : 30
Reconnect Interval       : 15
Configured TCP MSS       : 700
Applied TCP MSS          : 700
Preferred TCP MSS        : NA
Address List received    : 3.3.3.3
                          20.20.20.2

Received Labels :      Fec          Label      Maps To
Sent Labels :    Fec          Label      Maps To

```

R2

```

R2#show ldp session
Codes: m - MD5 password is not set/unset.
      g - GR configuration not set/unset.
      t - TCP MSS not set/unset.
      Session has to be cleared manually

Code  Peer IP Address      IF Name   My Role   State      KeepAlive  UpTime
     3.3.3.3              xe1      Passive  OPERATIONAL 30      00:13:39
     1.1.1.1              xe2      Active   OPERATIONAL 30      00:13:39

R2#show ldp session 3.3.3.3
Session state           : OPERATIONAL
Session role            : Passive
TCP Connection          : Established
IP Address for TCP      : 3.3.3.3
Interface being used    : xe1
Peer LDP ID             : 3.3.3.3:0
Preferred Peer LDP Password : Not Set
Adjacencies             : 20.20.20.2
Advertisement mode      : Downstream Unsolicited
Label retention mode    : Liberal
Graceful Restart        : Not Capable
Keepalive Timeout       : 30
Reconnect Interval      : 15
Configured TCP MSS      : 710
Applied TCP MSS         : 710
Preferred TCP MSS       : NA
Address List received   : 3.3.3.3
                          20.20.20.2

Received Labels :      Fec          Label      Maps To
                IPV4:20.20.20.0/24    impl-null    none
                IPV4:3.3.3.3/32       impl-null    25601
Sent Labels :    Fec          Label      Maps To
                IPV4:20.20.20.0/24    impl-null    none
                IPV4:10.10.10.0/24    impl-null    none
                IPV4:2.2.2.2/32       impl-null    none
                IPV4:1.1.1.1/32       25600       impl-null

R2#show ldp session 1.1.1.1
Session state           : OPERATIONAL

```

```

Session role           : Active
TCP Connection         : Established
IP Address for TCP     : 1.1.1.1
Interface being used   : xe2
Peer LDP ID            : 1.1.1.1:0
Preferred Peer LDP Password : Not Set
Adjacencies            : 10.10.10.1
Advertisement mode      : Downstream Unsolicited
Label retention mode    : Liberal
Graceful Restart       : Not Capable
Keepalive Timeout      : 30
Reconnect Interval     : 15
Configured TCP MSS     : 710
Applied TCP MSS        : 700
Preferred TCP MSS       : NA
Address List received   : 1.1.1.1
                        10.10.10.1

```

Received Labels :	Fec	Label	Maps To
	IPV4:48.48.48.48/32	impl-null	none
	IPV4:10.10.10.0/24	impl-null	none
	IPV4:1.1.1.1/32	impl-null	25600
Sent Labels :	Fec	Label	Maps To
	IPV4:20.20.20.0/24	impl-null	none
	IPV4:10.10.10.0/24	impl-null	none
	IPV4:3.3.3.3/32	25601	impl-null
	IPV4:2.2.2.2/32	impl-null	none

R3

```

R3#show ldp session 2.2.2.2
Session state           : OPERATIONAL
Session role            : Active
TCP Connection          : Established
IP Address for TCP      : 2.2.2.2
Interface being used    : xe1
Peer LDP ID             : 2.2.2.2:0
Preferred Peer LDP Password : Not Set
Adjacencies             : 20.20.20.1
Advertisement mode       : Downstream Unsolicited
Label retention mode     : Liberal
Graceful Restart        : Not Capable
Keepalive Timeout       : 30
Reconnect Interval      : 15
Configured TCP MSS      : 720
Applied TCP MSS         : 710
Preferred TCP MSS        : NA
Address List received    : 2.2.2.2
                        10.10.10.2
                        20.20.20.1

```

Received Labels :	Fec	Label	Maps To
	IPV4:20.20.20.0/24	impl-null	none

```

          IPV4:10.10.10.0/24      impl-null      none
          IPV4:2.2.2.2/32        impl-null      none
          IPV4:1.1.1.1/32        25600         none
Sent Labels :   Fec              Label          Maps To
          IPV4:20.20.20.0/24     impl-null      none
          IPV4:3.3.3.3/32        impl-null      none
R3#show ldp session 1.1.1.1
Session state           : OPERATIONAL
Session role            : Active
TCP Connection          : Established
IP Address for TCP      : 1.1.1.1
Interface being used    : xe1
Peer LDP ID             : 1.1.1.1:0
Preferred Peer LDP Password : Not Set
Adjacencies             : 1.1.1.1
Advertisement mode      : Downstream Unsolicited
Label retention mode    : Liberal
Graceful Restart        : Not Capable
Keepalive Timeout       : 30
Reconnect Interval      : 15
Configured TCP MSS      : 720
Applied TCP MSS         : 700
Preferred TCP MSS       : NA
Address List received   : 1.1.1.1
                        10.10.10.1
Received Labels :      Fec              Label          Maps To
Sent Labels :   Fec              Label          Maps To

```

Configuration of TCP MSS with Auto-targeted

R1 - NSM

R1#configure terminal	Enter configure mode.
R1(config)#interface xe1	Specify the interface xe1 to be configured.
R1(config-if)#ip address 10.10.10.1/24	Assign IP address 10.10.10.1/24 to interface.
R1(config-if)#label-switching	Enable label switching on interface xe1.
R1(config-if)#exit	Exit interface mode.
R1(config)#interface lo	Specify the loopback interface to be configured.
R1(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/ 32.
R1(config-if)#commit	Commit the transaction.

R1 - LDP

R1(config)#router ldp	Enter Router mode for LDP.
R1(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1.

R1(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter <code>ipv6</code> if you are configuring an IPv6 interface.
R1(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted peer.
R1(config-router-targeted-peer)#exit	Exit-targeted-peer-mode.
R1(config-router)#exit	Exit the Router mode and return to the configure mode.
R1(config)#interface xe1	Enter interface mode.
R1(config-if)#enable-ldp ipv4	Enable LDP on xe1.
R1(config-if)#commit	Commit the transaction.

R1 - OSPF

R1(config)#router ospf 100	Configure the routing process and specify the process ID (100). The process ID should be a unique positive integer identifying the routing process.
R1(config-router)#network 10.10.10.0/24 area 0	Define the interface 10.10.10.0/24, on which OSPF runs and associate the area ID (0) with the interface.
R1(config-router)#network 1.1.1.1/32 area 0	Define the interface 1.1.1.1/32, on which OSPF runs and associate the area ID (0) with the interface.
R1(config-router)#commit	Commit the transaction.

R2 - NSM

R2#configure terminal	Enter configure mode.
R2(config)#interface lo	Specify the loopback interface to be configured.
R2(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe1	Specify the interface xe1 to be configured.
R2(config-if)#ip address 20.20.20.1/24	Assign IP address 20.20.20.1/24 to interface.
R2(config-if)#label-switching	Enable label switching on interface xe1.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe2	Specify the interface xe2 to be configured.
R2(config-if)#ip address 10.10.10.2/24	Assign IP address 10.10.10.2/24 to interface.
R2(config-if)#label-switching	Enable label switching on interface xe2.
R2(config-if)#commit	Commit the transaction.

R2 - LDP

R2(config)#router ldp	Enter Router mode.
R2(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.

R2(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter <code>ipv6</code> if you are configuring an IPv6 interface.
R2(config-router)#neighbor auto-targeted tcp-mss 800	Configure the TCP MSS value on all auto-targeted neighbors.
R2(config-router)#exit	Exit Router mode and return to configure mode.
R2(config)#interface xe1	Specify the interface <code>xe1</code> to be configured.
R2(config-if)#enable-ldp ipv4	Enable LDP on a specified interface <code>xe1</code> .
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe2	Specify the interface <code>xe2</code> to be configured.
R2(config-if)#enable-ldp ipv4	Enable LDP on a specified interface <code>xe2</code> .
R2(config-if)#commit	Commit the transaction.

R2 - OSPF

R2(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
R2(config-router)#network 10.10.10.0/24 area 0	Define the interfaces <code>10.10.10.0/24</code> , on which OSPF runs and associate the area ID (0) with them.
R2(config-router)#network 20.20.20.0/24 area 0	Define the interfaces <code>20.20.20.0/24</code> , on which OSPF runs and associate the area ID (0) with them.
R2(config-router)#network 2.2.2.2/32 area 0	Define the interfaces <code>2.2.2.2/32</code> , on which OSPF runs and associate the area ID (0) with them.
R2(config-router)#commit	Commit the transaction.

R3 - NSM

R3#configure terminal	Enter configure mode.
R3(config)#interface lo	Specify the loopback interface to be configured.
R3(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to <code>3.3.3.3/32</code> .
R3(config-if)#exit	Exit interface mode.
R3(config)#interface xe1	Specify the interface <code>xe1</code> to be configured.
R3(config-if)#ip address 20.20.20.2/24	Set the IP address of the interface to <code>20.20.20.2/24</code> .
R3(config-if)#label-switching	Enable label switching on interface <code>xe1</code> .
R3(config-if)#commit	Commit the transaction.

R3 - LDP

R3(config)#router ldp	Enter Router mode.
R3(config-router)#router-id 3.3.3.3	Set the router ID for IP address <code>3.3.3.3</code> .

R3(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter <code>ipv6</code> if you are configuring an IPv6 interface.
R3(config-router)#neighbor auto-targeted tcp-mss 810	Configure the TCP MSS value on all auto-targeted neighbors.
R3(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
R3(config-router-targeted-peer)#exit	Exit-targeted-peer-mode.
R3(config-router)#exit	Exit the Router mode and return to the configure mode.
R3(config)#interface xe1	Enter interface mode <code>xe1</code> .
R3(config-if)#enable-ldp ipv4	Enable LDP on <code>xe1</code> .
R3(config-if)#commit	Commit the transaction.

R3 - OSPF

R3(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
R3(config-router)#network 20.20.20.0/24 area 0	Define the interfaces 20.20.20.0/24, on which OSPF runs and associate the area ID (0) with them.
R3(config-router)#network 3.3.3.3/32 area 0	Define the interfaces 3.3.3.3/32, on which OSPF runs and associate the area ID (0) with them.
R3(config-router)#commit	Commit the transaction.

Validation

R1

R1#show ldp session

Codes: m - MD5 password is not set/unset.
g - GR configuration not set/unset.
t - TCP MSS not set/unset.
Session has to be cleared manually

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	2.2.2.2	xe1	Passive	OPERATIONAL	30	00:00:03
	3.3.3.3	xe1	Passive	OPERATIONAL	30	00:00:03

R1#show ldp targeted-peers

IP Address	Interface
3.3.3.3	xe1

R1#show ldp session 3.3.3.3

Session state	: OPERATIONAL
Session role	: Passive
TCP Connection	: Established
IP Address for TCP	: 3.3.3.3
Interface being used	: xe1

```

Peer LDP ID           : 3.3.3.3:0
Preferred Peer LDP Password : Not Set
Adjacencies           : 3.3.3.3
Advertisement mode     : Downstream Unsolicited
Label retention mode   : Liberal
Graceful Restart      : Not Capable
Keepalive Timeout     : 30
Reconnect Interval    : 15
Configured TCP MSS    : Not configured
Applied TCP MSS       : 810
Preferred TCP MSS     : NA
Address List received : 3.3.3.3

```

20.20.20.2

Received Labels :	Fec	Label	Maps To
	IPV4:20.20.20.0/24	25604	none
	IPV4:3.3.3.3/32	25603	none
	IPV4:10.10.10.0/24	25602	none
	IPV4:2.2.2.2/32	25601	none
	IPV4:1.1.1.1/32	25600	none
Sent Labels :	Fec	Label	Maps To
	IPV4:10.10.10.0/24	25604	none
	IPV4:1.1.1.1/32	25603	none
	IPV4:20.20.20.0/24	25602	impl-null
	IPV4:3.3.3.3/32	25601	25601
	IPV4:2.2.2.2/32	25600	impl-null

R2

R2#show ldp session

```

Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
Session has to be cleared manually

```

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	3.3.3.3	xe1	Passive	OPERATIONAL	30	00:00:04
	1.1.1.1	xe2	Active	OPERATIONAL	30	00:00:04

R2#show ldp targeted-peers

R2#show ldp session 3.3.3.3

```

Session state           : OPERATIONAL
Session role            : Passive
TCP Connection          : Established
IP Address for TCP      : 3.3.3.3
Interface being used    : xe1
Peer LDP ID             : 3.3.3.3:0
Preferred Peer LDP Password : Not Set
Adjacencies             : 20.20.20.2
Advertisement mode      : Downstream Unsolicited
Label retention mode    : Liberal
Graceful Restart        : Not Capable
Keepalive Timeout       : 30
Reconnect Interval      : 15

```

```

Configured TCP MSS      : Not configured
Applied TCP MSS         : 1460
Preferred TCP MSS       : NA
Address List received   : 3.3.3.3
                        20.20.20.2

```

```

Received Labels :      Fec          Label          Maps To
                   IPV4:20.20.20.0/24    impl-null      none
                   IPV4:3.3.3.3/32       impl-null      25601
Sent Labels :    Fec          Label          Maps To
                   IPV4:20.20.20.0/24    impl-null      none
                   IPV4:10.10.10.0/24    impl-null      none
                   IPV4:2.2.2.2/32       impl-null      none
                   IPV4:1.1.1.1/32       25600         impl-null

```

R3

```
R3#show ldp session
```

```

Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

```

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	2.2.2.2	xe1	Active	OPERATIONAL	30	00:02:15
	1.1.1.1	xe1	Active	OPERATIONAL	30	00:02:15

```
R3#show ldp targeted-peers
```

```

IP Address      Interface
1.1.1.1         xe1

```

```
PE2#show ldp session 1.1.1.1
```

```

Session state      : OPERATIONAL
Session role       : Active
TCP Connection     : Established
IP Address for TCP : 1.1.1.1
Interface being used : xe1
Peer LDP ID        : 1.1.1.1:0
Preferred Peer LDP Password : Not Set
Adjacencies        : 1.1.1.1
Advertisement mode  : Downstream Unsolicited
Label retention mode : Liberal
Graceful Restart   : Not Capable
Keepalive Timeout  : 30
Reconnect Interval : 15
Configured TCP MSS : 810
Applied TCP MSS    : 810
Preferred TCP MSS   : NA
Address List received : 1.1.1.1
                    10.10.10.1

```

```

Received Labels :      Fec          Label          Maps To
                   IPV4:10.10.10.0/24    25604          none
                   IPV4:1.1.1.1/32       25603          none
                   IPV4:20.20.20.0/24    25602          none
                   IPV4:3.3.3.3/32       25601          none

```

Sent Labels :	IPV4:2.2.2.2/32	25600	none
	Fec	Label	Maps To
	IPV4:20.20.20.0/24	25604	none
	IPV4:3.3.3.3/32	25603	none
	IPV4:10.10.10.0/24	25602	impl-null
	IPV4:2.2.2.2/32	25601	impl-null
	IPV4:1.1.1.1/32	25600	25600

New CLI Command

neighbor tcp-mss

Use this command to set the TCP MSS for an LDP session. MSS is a TCP parameter that defines the maximum amount of data in a TCP segment that can be transmitted.

Use the `no` command to remove the TCP MSS from an LDP session.

Command Syntax

```
neighbor (A.B.C.D | auto-targeted | all) tcp-mss <560-1440>
no neighbor (A.B.C.D | auto-targeted | all) tcp-mss
```

Parameters

A.B.C.D	To set MSS for the specific peer.
auto-targeted	To set MSS for auto-targeted LDP peer. Auto-targeted LDP sessions automatically establish the TCP connection with neighboring routers and do not require the manual configuration of each peer.
all	To set MSS for all LDP peers
<560-1440>	Configure the TCP MSS between this range.

Default

By default, `neighbor tcp-mss` is disabled and the MSS value is 1460 bytes.

Command Mode

Router LDP mode.

Applicability

This command was introduced in OcNOS version 6.4.1.

Examples

```
OcNOS(config)#router ldp
OcNOS(config-router)#neighbor 2.2.2.2 tcp-mss 900
OcNOS(config-router)#neighbor all tcp-mss 1000
OcNOS(config-router)#neighbor auto-targeted tcp-mss 800
OcNOS(config-router)#commit
```

Abbreviations

The following are some key abbreviations and their meanings relevant to this document:

Acronym	Description
ACK	Acknowledgment
IGP	Interior Gateway Protocol
LDP	Label Distribution Protocol
MSS	Maximum Segment Size
MTU	Maximum Transmission Unit
OSPF	Open Short Path First
SYN	Synchronize
TCP	Transmission Control Protocol

Glossary

The following provides definitions for key terms used throughout this document:

LDP	LDP is a routing protocol that manages and distributes the labels to the route in a Multiprotocol Label Switching (MPLS) network. Adding a label to a route helps to control the flow of network traffic and increases the forwarding speed, ensuring a smooth and optimized data transmission.
LDP session	LDP session is the connection established between LDP routers in an MPLS network.
MSS	MSS is a TCP parameter that defines the maximum amount of data in a TCP segment that can be transmitted.
TCP	TCP is one of the main protocols in the Internet Protocol (IP) suite. It offers a secure and reliable connection between two devices.
TCP segment	TCP segment is a unit of data transmitted in a TCP connection. The segment consists of header and payload. The header contains the control information to manage the transmission, and the payload contains the actual data that needs to be transmitted.

CHAPTER 6 LDP Remote Loop-Free Alternate (RLFA)

A basic mechanism using Loop-Free Alternates (LFAs) is described in RFC5286 that provides good repair coverage in many topologies, especially those that are highly meshed.

However, some topologies, notably ring-based topologies, are not well protected by LFAs alone. This is because there is no neighbor of the Point of Local Repair (PLR) that has a cost to the destination via a path that does not traverse the failure that is cheaper than the cost to the destination via the failure.

RFC 7490 provides extensions to the basic repair mechanism in which tunnels are used to provide additional logical links that can be used as loop-free alternates where none exist in the original topology. It provides loop-free alternates that guarantee only link protection.

RFC 8102 provides remote-loop-free-based IP fast reroute mechanisms that specifies procedures for determining whether or not a given PQ-node provides node protection for a specific destination. It provides node protection for all destinations covered by the same remote-LFA alternate, in case of failure of the primary next-hop node

ISIS shall compute PQ node and LDP shall dynamically create tunnel to PQ node so that if primary path fails traffic can be rerouted to backup rLFA tunnel and hence to destination.

Remote LFA involves the use of a tunnel to a next-hop that is not directly connected. This is the primary difference between the LFA and Remote LFA.

RLFA Terminology

Terms used for defining tunnel as below:

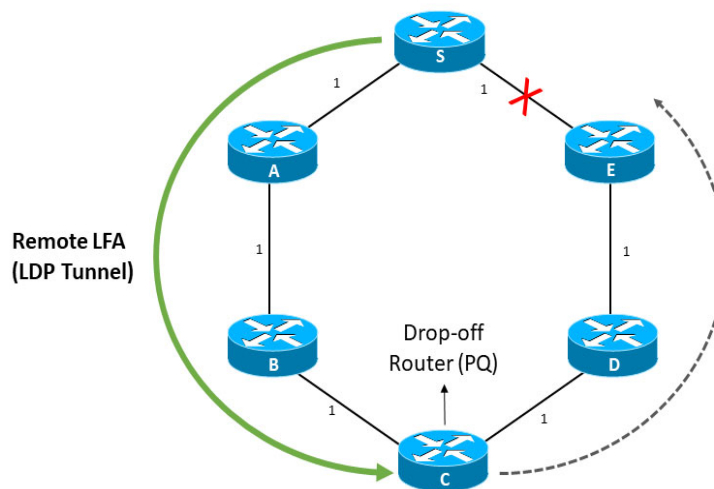


Figure 6-6: Understanding RLFA

Repair tunnel

A tunnel established for the purpose of providing a virtual neighbor that is a Loop-Free Alternate.

P-space

The P-space of a router with respect to a protected link is the set of routers reachable from that specific router using the pre-convergence shortest paths, without any of those paths (including equal cost path splits) transiting that protected link.

For example, the P-space of S with respect to link S-E is the set of routers that S can reach without using the protected link S-E.

Extended P-space

Consider the set of neighbors of a router protecting a link. Exclude the router reachable over the protected link from that set of routers. The extended P-space of the protecting router with respect to the protected link is the union of the P spaces of the neighbors in that set of neighbors with respect to the protected link.

Q-space

Q-space of a router with respect to a protected link is the set of routers from which that specific router that can be reached without any path (including ECMP Splits) transiting that protected link.

PQ node

A PQ node of a node S with respect to a protected link S-E is a node that is a member of both the P-space (or the extended P-space) of S with respect to that protected link S-E and the Q-space of E with respect to that protected link S-E. A repair tunnel endpoint is chosen from the set of PQ-nodes.

Remote LFA (RLFA)

The use of a PQ node rather than a neighbor of the repairing node as the next hop in an LFA repair.

In [Figure 6-6](#), S can reach A, B, and C without going via S-E; these form S's extended P-space with respect to S-E. The routers that can reach E without going through S-E will be in E's Q-space with respect to link S-E; these are D and C. B has equal-cost paths to E via B-A-S-E and B-C-D-E, and so the forwarder at S might choose to send a packet to E via link S-E. Hence, B is not in the Q-space of E with respect to link S-E. The single node in both S's extended P-space and E's Q-space is C; thus, node C is selected as the repair tunnel's endpoint. Thus, if a tunnel is provided between S and C as shown in Figure 2, then C, now being a direct neighbor of S, would become an LFA for D and E.

Establishing RLFA Tunnel

To calculate the Remote LFA backup path and to determine the Remote LFA node the software requirement can be broadly classified as below:

IS-IS

ISIS shall calculate Repair path that are P space (routers it can reach without traversing the protected link) and Q space (routers that can reach the protected destination without traversing the protected link). Hence routers that belong to both spaces called as PQ routers has to be calculated. It has to inform LDP about PQ node so that RLFA tunnel can be established.

LDP

LDP shall establish targeted session with PQ node and shall advertise label to peer node for the destination FEC. LDP shall send primary and backup path FTN/ILM add/delete info to NSM for further programming.

NSM

NSM shall maintain Primary and Backup path FTN/ILM and shall send information to HSL for data-plane programming.

HSL

HSL program primary and backup FTN/ILM entry in hardware.

Configure LDP Remote Loop-Free Alternate (RLFA)

The LDP RLFA configuration process can be divided into the following tasks:

1. Enable label-switching on the interface on NSM.
2. Establish ISIS routing between the nodes (to distribute reachability information within the MPLS cloud)
3. Configure ISIS RLFA on Source node
4. Enabling LDP on an interface in the LDP daemon
5. Configure LDP FRR with Auto-targeted-session (Allow creating TLDP session dynamically)
6. Enable BFD interval globally and for all ISIS enabled interfaces

Note: Faster convergence can be achieved with lower BFD interval enabled globally.

Note: Dynamically created RLFA T-LDP sessions will be removed only after disabling LDP `auto-targeted-session` CLI or LDP FRR.

Note: When `targeted-peer ipv4` CLI is configured with `auto-targeted-session` CLI, T-LDP session created for targeted-peer only remove after disabling `auto-targeted-session` CLI.

Note: After Enabling ISIS RLFA, Both LFA and RLFA computation will be done and RLFA path will be preferred to provide node-protection.

Note: Better convergence can be achieved with LDP-IGP-SYNC enabled.

Assumptions and limitations

- RLFA Backup path computation will be supported only via IGP as IS-IS.
- Only LDP(MPLS) will be used as a tunnel mechanism to reach a Remote-LFA repair node.
- Only IPv4 protocol is supported.
- RFC 7916 [LFA-MANAGE] is not supported.
- ECMP will not be supported for RLFA next-hop.

Topology

Figure 6-7 shows the configuration required to enable the RLFA feature.

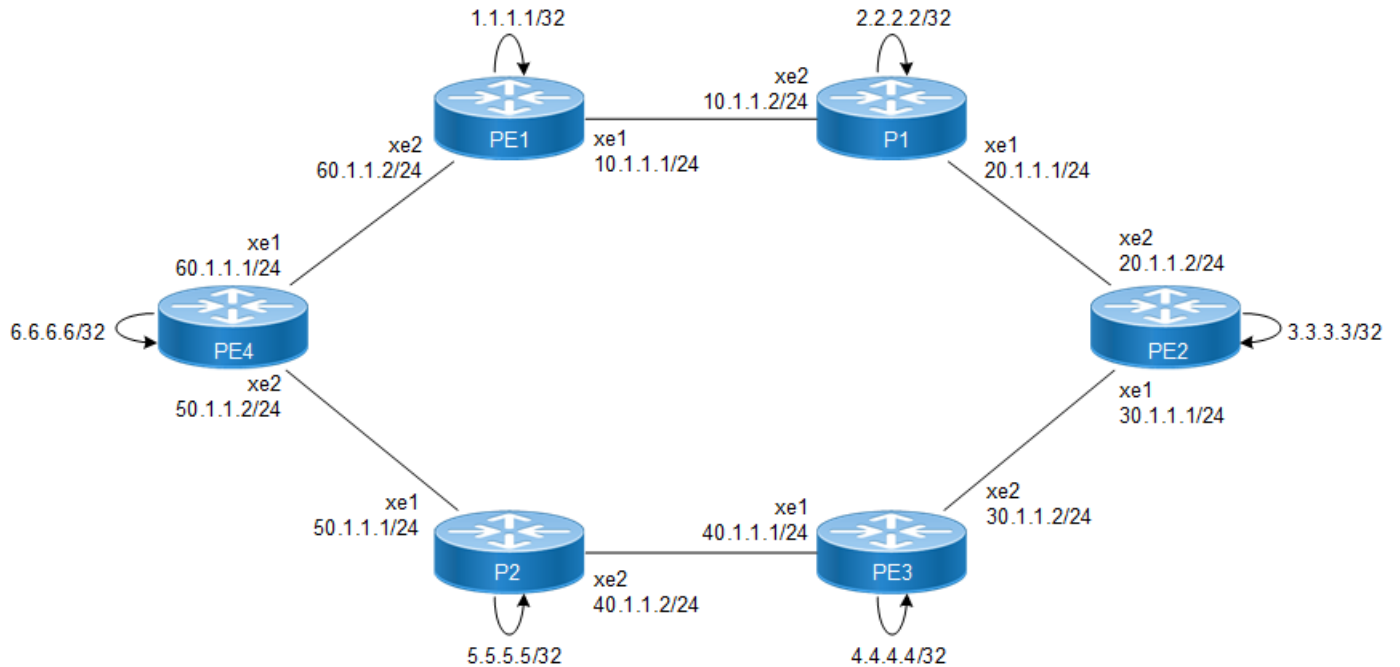


Figure 6-7: RLFA Topology

Configuration

PE1

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa)
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 60.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#label-switching	Enable label-switching on interface

(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 1.1.1.1/32 secondary	Configure the IP address of the interface
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#exit	Exit interface mode.
(config)#router isis rlfa	Create an IS-IS routing instance for area 49 (rlfa).
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)# mpls traffic-eng router-id 1.1.1.1	Configure MPLS-TE unique router-id TLV.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
(config-router)# net 49.0000.0000.0001.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)# fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp	Configure Remote LFA to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
(config-router)# bfd all-interfaces	Enable the Bidirectional Forwarding Detection (BFD) feature on the interfaces enabled with this ISIS instance.
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#end	Exit router mode.
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally

P1

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 10.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa)
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.

(config)#interface xe1	Enter interface mode.
(config-if)#ip address 20.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Configure the IP address of the interface
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#router isis rlfa	Create an IS-IS routing instance for area 49 (rlfa).
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)# mpls traffic-eng router-id 1.1.1.1	Configure MPLS-TE unique router-id TLV.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
(config-router)# net 49.0000.0000.0002.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)# bfd all-interfaces	Enable the Bidirectional Forwarding Detection (BFD) feature on the interfaces enabled with this ISIS instance.
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit router mode.
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration

PE2

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 20.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa)

(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 30.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 3.3.3.3/32 secondary	Configure the IP address of the interface
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#router isis rlfa	Create an IS-IS routing instance for area 49 (rlfa).
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)# mpls traffic-eng router-id 3.3.3.3	Configure MPLS-TE unique router-id TLV.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
(config-router)# net 49.0000.0000.0003.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)# bfd all-interfaces	Enable the Bidirectional Forwarding Detection (BFD) feature on the interfaces enabled with this ISIS instance.
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit router mode.
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration

PE3

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically

(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 30.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa)
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 40.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 4.4.4.4/32 secondary	Configure the IP address of the interface
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#exit	Exit interface mode.
(config)#router isis rlfa	Create an IS-IS routing instance for area 49 (rlfa).
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)# mpls traffic-eng router-id 4.4.4.4	Configure MPLS-TE unique router-id TLV.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
(config-router)# net 49.0000.0000.0004.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)# bfd all-interfaces	Enable the Bidirectional Forwarding Detection (BFD) feature on the interfaces enabled with this ISIS instance.
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit router mode.
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration

P2

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 40.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa)
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 50.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 5.5.5.5/32 secondary	Configure the IP address of the interface
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#exit	Exit interface mode.
(config)#router isis rlfa	Create an IS-IS routing instance for area 49 (rlfa).
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)# mpls traffic-eng router-id 5.5.5.5	Configure MPLS-TE unique router-id TLV.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
(config-router)# net 49.0000.0000.0005.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)# bfd all-interfaces	Enable the Bidirectional Forwarding Detection (BFD) feature on the interfaces enabled with this ISIS instance.
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit router mode.

(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration

PE4

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 50.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa)
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 60.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 6.6.6.6/32 secondary	Configure the IP address of the interface
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#exit	Exit interface mode.
(config)#router isis rlfa	Create an IS-IS routing instance for area 49 (rlfa).
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)# mpls traffic-eng router-id 6.6.6.6	Configure MPLS-TE unique router-id TLV.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
(config-router)# net 49.0000.0000.0005.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.

(config-router)# bfd all-interfaces	Enable the Bidirectional Forwarding Detection (BFD) feature on the interfaces enabled with this ISIS instance.
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit router mode.
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration

Validation

PE1

Check LDP neighborship before enabling RLFA

```
PE1#show ldp session
```

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe1	Passive	OPERATIONAL	30	00:02:19
6.6.6.6	xe2	Passive	OPERATIONAL	30	00:02:19

Check the output of "show clns neighbors" to verify that ISIS adjacency is up.

```
PE1#show clns neighbors
```

Total number of L1 adjacencies: 2

Total number of L2 adjacencies: 0

Total number of adjacencies: 2

Tag rlfa: VRF : default

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
0000.0000.0006	xe2	e8c5.7a78.7132	Up	23	L1	IS-IS
0000.0000.0002	xe1	e8c5.7a98.c48a	Up	23	L1	IS-IS

Check the ISIS route installation in the ISIS table and RIB table.

```
PE1#show ip isis route
```

Codes: C - connected, E - external, L1 - IS-IS level-1, L2 - IS-IS level-2
 ia - IS-IS inter area, D - discard, e - external metric
 ** - invalid

Tag rlfa: VRF : default

	Destination	Metric	Next-Hop	Interface	Tag
C	1.1.1.1/32	10	--	lo	0
L1	2.2.2.2/32	20	10.1.1.2	xe1	0
L1	3.3.3.3/32	30	10.1.1.2	xe1	0
L1	4.4.4.4/32	40	10.1.1.2	xe1	0
			60.1.1.1	xe2	0
L1	5.5.5.5/32	30	60.1.1.1	xe2	0
L1	6.6.6.6/32	20	60.1.1.1	xe2	0

C	10.1.1.0/24	10	--	xe1	0
L1	20.1.1.0/24	20	10.1.1.2	xe1	0
L1	30.1.1.0/24	30	10.1.1.2	xe1	0
L1	40.1.1.0/24	30	60.1.1.1	xe2	0
L1	50.1.1.0/24	20	60.1.1.1	xe2	0
C	60.1.1.0/24	10	--	xe2	0

PE1#show ip route

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
 O - OSPF, IA - OSPF inter area
 N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
 E1 - OSPF external type 1, E2 - OSPF external type 2
 i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
 ia - IS-IS inter area, E - EVPN,
 v - vrf leaked
 * - candidate default

IP Route Table for VRF "default"

```

C          1.1.1.1/32 is directly connected, lo, 01:52:43
i L1      2.2.2.2/32 [115/20] via 10.1.1.2, xe1, 00:27:36
i L1      3.3.3.3/32 [115/30] via 10.1.1.2, xe1, 00:27:36
i L1      4.4.4.4/32 [115/40] via 60.1.1.1, xe2, 00:27:36
           [115/40] via 10.1.1.2, xe1
i L1      5.5.5.5/32 [115/30] via 60.1.1.1, xe2, 00:27:36
i L1      6.6.6.6/32 [115/20] via 60.1.1.1, xe2, 00:27:36
C          10.1.1.0/24 is directly connected, xe1, 01:52:42
i L1      20.1.1.0/24 [115/20] via 10.1.1.2, xe1, 00:27:36
i L1      30.1.1.0/24 [115/30] via 10.1.1.2, xe1, 00:27:36
i L1      40.1.1.0/24 [115/30] via 60.1.1.1, xe2, 00:27:36
i L1      50.1.1.0/24 [115/20] via 60.1.1.1, xe2, 00:27:36
C          60.1.1.0/24 is directly connected, xe2, 01:52:42
C          127.0.0.0/8 is directly connected, lo, 01:54:18

```

Gateway of last resort is not set

Verify ISIS LFA and RLFA backup computed paths for Primary Paths

PE1# show ip isis route fast-reroute

Tag : rlfa VRF : default
 Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
 D - discard, LP - Link Protecting, NP - Node Protecting,
 BP - Broadcast Interface Disjoint, Pri - Primary Path,
 Sec - Secondary Path, DP - Downstream Path

```

L1 2.2.2.2/32
Primary Path via : 10.1.1.2, xe1
Remote FRR Path via : 4.4.4.4, via : 60.1.1.1, xe2
FRR Metric : 60
Protection Provided : LP

```

L1 3.3.3.3/32
Primary Path via : 10.1.1.2, xe1
Remote FRR Path via : 4.4.4.4, via : 60.1.1.1, xe2
FRR Metric : 50
Protection Provided : LP NP DP

L1 4.4.4.4/32
Primary Path via : 10.1.1.2, xe1
FRR Backup Path via : 60.1.1.1, xe2
FRR Metric : 40
Protection Provided : LP NP BP Pri DP

Primary Path via : 60.1.1.1, xe2
FRR Backup Path via : 10.1.1.2, xe1
FRR Metric : 40
Protection Provided : LP NP BP Pri DP

L1 5.5.5.5/32
Primary Path via : 60.1.1.1, xe2
Remote FRR Path via : 4.4.4.4, via : 10.1.1.2, xe1
FRR Metric : 50
Protection Provided : LP NP DP

L1 6.6.6.6/32
Primary Path via : 60.1.1.1, xe2
Remote FRR Path via : 4.4.4.4, via : 10.1.1.2, xe1
FRR Metric : 60
Protection Provided : LP

L1 20.1.1.0/24
Primary Path via : 10.1.1.2, xe1
Remote FRR Path via : 4.4.4.4, via : 60.1.1.1, xe2
FRR Metric : 60
Protection Provided : LP

L1 30.1.1.0/24
Primary Path via : 10.1.1.2, xe1
FRR Backup Path via : 60.1.1.1, xe2
FRR Metric : 40
Protection Provided : LP NP BP

L1 40.1.1.0/24
Primary Path via : 60.1.1.1, xe2
FRR Backup Path via : 10.1.1.2, xe1
FRR Metric : 40
Protection Provided : LP NP BP

L1 50.1.1.0/24
Primary Path via : 60.1.1.1, xe2

```

Remote FRR Path via : 4.4.4.4, via : 10.1.1.2, xe1
FRR Metric           : 60
Protection Provided  : LP

```

Verify PQ node which is near to source is selected and Target-LDP session is established with PQ node using below commands

```

PE1#show ldp session
Peer IP Address      IF Name    My Role    State        KeepAlive  UpTime
2.2.2.2              xe2        Passive    OPERATIONAL  30         00:05:37
6.6.6.6              xe1        Passive    OPERATIONAL  30         00:05:37
4.4.4.4              xe1        Passive    OPERATIONAL  30         00:05:21

PE1#show ldp targeted-peers
IP Address           Interface
4.4.4.4              xe1    > PE1 established T-LDP with PE3 (since PE3 is PQ for PE1)

```

Verify that Primary and Backup FTN's are installed with labels in LDP RLFA route table

```

PE1#sh ldp rlfa-routes
Fec          Primary-NH    Backup-NH    rLFA-Addr    Out-Intf  Outer-label
Inner-label
2.2.2.2      10.1.1.2              60.1.1.1     4.4.4.4      xe1        24962      24329
3.3.3.3      10.1.1.2              60.1.1.1     4.4.4.4      xe1        24962      24330
5.5.5.5      60.1.1.1              10.1.1.2     4.4.4.4      xe2        24321      24331
6.6.6.6      60.1.1.1              10.1.1.2     4.4.4.4      xe2        24321      24332
20.1.1.0     10.1.1.2              60.1.1.1     4.4.4.4      xe1        24962      24334
50.1.1.0     60.1.1.1              10.1.1.2     4.4.4.4      xe2        24321      24335

```

Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify the same in FTN table.

```

PE1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code  FEC          FTN-ID  Nhlfe-ID  Tunnel-id  Pri  LSP-Type  Out-Label
Out-Intf  ELC    Nexthop
L>  2.2.2.2/32    1        2        -          Yes  LSP_DEFAULT  3
xe1      No     10.1.1.2
          29
xe2      No     4.4.4.4
          (via
60.1.1.1 ,label 24962)
L>  3.3.3.3/32    3        10       -          Yes  LSP_DEFAULT  24320
xe1      No     10.1.1.2

```

xe2	No	4.4.4.4	30	-	No	LSP_DEFAULT	24330	
								(via
60.1.1.1 ,label 24962)								
L>	4.4.4.4/32	2	8	-	Yes	LSP_DEFAULT	24962	
xe2	No	60.1.1.1	11	-	No	LSP_DEFAULT	24321	
xe1	No	10.1.1.2	11	-	Yes	LSP_DEFAULT	24321	
xe1	No	10.1.1.2	7	-	No	LSP_DEFAULT	24962	
xe2	No	60.1.1.1	14	-	Yes	LSP_DEFAULT	24963	
L>	5.5.5.5/32	4	31	-	No	LSP_DEFAULT	24331	
xe2	No	60.1.1.1						(via
10.1.1.2 ,label 24321)								
L>	6.6.6.6/32	5	18	-	Yes	LSP_DEFAULT	3	
xe2	No	60.1.1.1	32	-	No	LSP_DEFAULT	24332	
xe1	No	4.4.4.4						(via
10.1.1.2 ,label 24321)								
L>	20.1.1.0/24	6	19	-	Yes	LSP_DEFAULT	3	
xe1	No	10.1.1.2	33	-	No	LSP_DEFAULT	24334	
xe2	No	4.4.4.4						(via
60.1.1.1 ,label 24962)								
L>	30.1.1.0/24	7	21	-	Yes	LSP_DEFAULT	24322	
xe1	No	10.1.1.2	22	-	No	LSP_DEFAULT	24964	
xe2	No	60.1.1.1	25	-	Yes	LSP_DEFAULT	24965	
L>	40.1.1.0/24	8	26	-	No	LSP_DEFAULT	24323	
xe2	No	60.1.1.1	28	-	Yes	LSP_DEFAULT	3	
xe1	No	10.1.1.2	34	-	No	LSP_DEFAULT	24335	
L>	50.1.1.0/24	9						(via
10.1.1.2 ,label 24321)								

PE1#sh mpls ftn-table

Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 10.1.1.2 cross connect ix: 2, op code: Push

Backup Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 29
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 29, owner: LDP, Stale: NO, out intf: xe2, out label: 24329
Nexthop addr: 4.4.4.4 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 24320
Nexthop addr: 10.1.1.2 cross connect ix: 7, op code: Push

Backup Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 30
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 30, owner: LDP, Stale: NO, out intf: xe2, out label: 24330
Nexthop addr: 4.4.4.4 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 24962
Nexthop addr: 60.1.1.1 cross connect ix: 3, op code: Push

Backup Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 11
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 24321
Nexthop addr: 10.1.1.2 cross connect ix: 3, op code: Push

Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 11
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 24321
Nexthop addr: 10.1.1.2 cross connect ix: 3, op code: Push

Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 24962
Nexthop addr: 60.1.1.1 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 13

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 13, owner: LDP, Stale: NO, out intf: xe2, out label: 24963
Nexthop addr: 60.1.1.1 cross connect ix: 8, op code: Push

Backup Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 31
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 31, owner: LDP, Stale: NO, out intf: xe1, out label: 24331
Nexthop addr: 4.4.4.4 cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 6.6.6.6/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 16
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 16, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 60.1.1.1 cross connect ix: 9, op code: Push

Backup Cross connect ix: 12, in intf: - in label: 0 out-segment ix: 32
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 32, owner: LDP, Stale: NO, out intf: xe1, out label: 24332
Nexthop addr: 4.4.4.4 cross connect ix: 11, op code: Push

Primary FTN entry with FEC: 20.1.1.0/24, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 10.1.1.2 cross connect ix: 2, op code: Push

Backup Cross connect ix: 14, in intf: - in label: 0 out-segment ix: 33
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 33, owner: LDP, Stale: NO, out intf: xe2, out label: 24334
Nexthop addr: 4.4.4.4 cross connect ix: 13, op code: Push

Primary FTN entry with FEC: 30.1.1.0/24, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 20
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 20, owner: LDP, Stale: NO, out intf: xe1, out label: 24322
Nexthop addr: 10.1.1.2 cross connect ix: 11, op code: Push

Backup Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 22
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 22, owner: LDP, Stale: NO, out intf: xe2, out label: 24964
 Nexthop addr: 60.1.1.1 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 40.1.1.0/24, id: 8, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
 none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Cross connect ix: 12, in intf: - in label: 0 out-segment ix: 24

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 24, owner: LDP, Stale: NO, out intf: xe2, out label: 24965
 Nexthop addr: 60.1.1.1 cross connect ix: 12, op code: Push

Backup Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 26

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 26, owner: LDP, Stale: NO, out intf: xe1, out label: 24323
 Nexthop addr: 10.1.1.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 50.1.1.0/24, id: 9, row status: Active, Tunnel-Policy: N/A
 Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
 none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 16

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 16, owner: N/A, Stale: NO, out intf: xe2, out label: 3
 Nexthop addr: 60.1.1.1 cross connect ix: 9, op code: Push

Backup Cross connect ix: 16, in intf: - in label: 0 out-segment ix: 34

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 34, owner: LDP, Stale: NO, out intf: xe1, out label: 24335
 Nexthop addr: 4.4.4.4 cross connect ix: 15, op code: Push

P1#show ldp session

Peer IP Address IF Name My Role State KeepAlive UpTime

1.1.1.1 xe2 Active OPERATIONAL 30 00:51:02

3.3.3.3 xe1 Passive OPERATIONAL 30 00:50:53

P1#

P1#

P1#show clns neighbors

Total number of L1 adjacencies: 2

Total number of L2 adjacencies: 0

Total number of adjacencies: 2

Tag rlfa: VRF : default

System Id Interface SNPA State Holdtime Type Protocol

PE1 xe2 5254.0073.cecf Up 6 L1 IS-IS

PE2 xe1 5254.0084.60d4 Up 22 L1 IS-IS

P1#

Check the ISIS route installation in the ISIS table and RIB table.

P1#show ip isis route

Codes: C - connected, E - external, L1 - IS-IS level-1, L2 - IS-IS level-2

ia - IS-IS inter area, D - discard, e - external metric


```
** - invalid
Tag rlfa: VRF : default
Destination Metric Next-Hop Interface Tag
L1 1.1.1.1/32 20 10.1.1.1 xe2 0
C 2.2.2.2/32 10 -- lo 0
L1 3.3.3.3/32 20 20.1.1.2 xe1 0
L1 4.4.4.4/32 30 20.1.1.2 xe1 0
L1 5.5.5.5/32 40 20.1.1.2 xe1 0
10.1.1.1 xe2 0
L1 6.6.6.6/32 30 10.1.1.1 xe2 0
C 10.1.1.0/24 10 -- xe2 0
C 20.1.1.0/24 10 -- xe1 0
L1 30.1.1.0/24 20 20.1.1.2 xe1 0
L1 40.1.1.0/24 30 20.1.1.2 xe1 0
L1 50.1.1.0/24 30 10.1.1.1 xe2 0
L1 60.1.1.0/24 20 10.1.1.1 xe2 0
P1#
P1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
ia - IS-IS inter area, E - EVPN,
v - vrf leaked
* - candidate default
IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
K* 0.0.0.0/0 [0/0] via 10.12.49.1, eth0
i L1 1.1.1.1/32 [115/20] via 10.1.1.1, xe2, 00:55:27
C 2.2.2.2/32 is directly connected, lo, 01:00:19
i L1 3.3.3.3/32 [115/20] via 20.1.1.2, xe1, 00:55:15
i L1 4.4.4.4/32 [115/30] via 20.1.1.2, xe1, 00:55:15
i L1 5.5.5.5/32 [115/40] via 10.1.1.1, xe2, 00:55:15
[115/40] via 20.1.1.2, xe1
i L1 6.6.6.6/32 [115/30] via 10.1.1.1, xe2, 00:55:03
C 10.1.1.0/24 is directly connected, xe2, 01:00:19
C 10.12.49.0/24 is directly connected, xe0, 01:06:48
C 20.1.1.0/24 is directly connected, xe1, 01:00:19
i L1 30.1.1.0/24 [115/20] via 20.1.1.2, xe1, 00:55:15
i L1 40.1.1.0/24 [115/30] via 20.1.1.2, xe1, 00:55:15
i L1 50.1.1.0/24 [115/30] via 10.1.1.1, xe2, 00:55:03
i L1 60.1.1.0/24 [115/20] via 10.1.1.1, xe2, 00:55:27
C 127.0.0.0/8 is directly connected, lo, 01:12:47
P1#show ldp targeted-peers
IP Address Interface
1.1.1.1 xe2
3.3.3.3 xe1
P1#
P1#
```

Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify the same in FTN table.

Pl#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code FEC FTN-ID Nhlfe-ID Tunnel-id Pri LSP-Type Out-Label Out-Intf ELC Nexthop

L> 1.1.1.1/32 1 1 - Yes LSP_DEFAULT 3 xe2 No 10.1.1.1

L> 3.3.3.3/32 3 2 - Yes LSP_DEFAULT 3 xe1 No 20.1.1.2

L> 4.4.4.4/32 4 3 - Yes LSP_DEFAULT 25600 xe1 No 20.1.1.2

L> 5.5.5.5/32 5 4 - Yes LSP_DEFAULT 25601 xe1 No 20.1.1.2

7 - Yes LSP_DEFAULT 25600 xe2 No 10.1.1.1

L> 6.6.6.6/32 9 8 - Yes LSP_DEFAULT 25601 xe2 No 10.1.1.1

L> 30.1.1.0/24 6 2 - Yes LSP_DEFAULT 3 xe1 No 20.1.1.2

L> 40.1.1.0/24 7 5 - Yes LSP_DEFAULT 25602 xe1 No 20.1.1.2

L> 50.1.1.0/24 8 9 - Yes LSP_DEFAULT 25603 xe2 No 10.1.1.1

L> 60.1.1.0/24 2 1 - Yes LSP_DEFAULT 3 xe2 No 10.1.1.1

Pl#show mpls ftn-table

Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3

Nexthop addr: 10.1.1.1 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3

Nexthop addr: 20.1.1.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe1, out label: 25600

Nexthop addr: 20.1.1.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25601
Nexthop addr: 20.1.1.2 cross connect ix: 5, op code: Push
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25600
Nexthop addr: 10.1.1.1 cross connect ix: 5, op code: Push
Primary FTN entry with FEC: 6.6.6.6/32, id: 9, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe2, out label: 25601
Nexthop addr: 10.1.1.1 cross connect ix: 8, op code: Push
Primary FTN entry with FEC: 30.1.1.0/24, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 20.1.1.2 cross connect ix: 3, op code: Push
Primary FTN entry with FEC: 40.1.1.0/24, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe1, out label: 25602
Nexthop addr: 20.1.1.2 cross connect ix: 6, op code: Push
Primary FTN entry with FEC: 50.1.1.0/24, id: 8, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe2, out label: 25603
Nexthop addr: 10.1.1.1 cross connect ix: 7, op code: Push
Primary FTN entry with FEC: 60.1.1.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

```

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 10.1.1.1 cross connect ix: 1, op code: Push
P1#
PE2#show ldp session
Peer IP Address IF Name My Role State KeepAlive UpTime
2.2.2.2 xe2 Active OPERATIONAL 30 01:14:28
4.4.4.4 xe1 Passive OPERATIONAL 30 01:14:27
PE2#
PE2#
PE2#
PE2#show clns neighbors
Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag rlfa: VRF : default
System Id Interface SNPA State Holdtime Type Protocol
P1 xe2 5254.00a6.9d27 Up 9 L1 IS-IS
PE3 xe1 5254.0076.2129 Up 21 L1 IS-IS
PE2#
Check the ISIS route installation in the ISIS table and RIB table.
PE2#show ip isis route
Codes: C - connected, E - external, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, D - discard, e - external metric
** - invalid

Tag rlfa: VRF : default
Destination Metric Next-Hop Interface Tag
L1 1.1.1.1/32 30 20.1.1.1 xe2 0
L1 2.2.2.2/32 20 20.1.1.1 xe2 0
C 3.3.3.3/32 10 -- lo 0
L1 4.4.4.4/32 20 30.1.1.2 xe1 0
L1 5.5.5.5/32 30 30.1.1.2 xe1 0
L1 6.6.6.6/32 40 30.1.1.2 xe1 0
20.1.1.1 xe2 0
L1 10.1.1.0/24 20 20.1.1.1 xe2 0
C 20.1.1.0/24 10 -- xe2 0
C 30.1.1.0/24 10 -- xe1 0
L1 40.1.1.0/24 20 30.1.1.2 xe1 0
L1 50.1.1.0/24 30 30.1.1.2 xe1 0
L1 60.1.1.0/24 30 20.1.1.1 xe2 0
PE2#
PE2#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
ia - IS-IS inter area, E - EVPN,
v - vrf leaked

```

```

* - candidate default
IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
K* 0.0.0.0/0 [0/0] via 10.12.49.1, xe0
i L1 1.1.1.1/32 [115/30] via 20.1.1.1, xe2, 01:18:10
i L1 2.2.2.2/32 [115/20] via 20.1.1.1, xe2, 01:18:31
C 3.3.3.3/32 is directly connected, lo, 01:23:03
i L1 4.4.4.4/32 [115/20] via 30.1.1.2, xe1, 01:18:23
i L1 5.5.5.5/32 [115/30] via 30.1.1.2, xe1, 01:18:23
i L1 6.6.6.6/32 [115/40] via 20.1.1.1, xe2, 01:18:10
[115/40] via 30.1.1.2, xe1
i L1 10.1.1.0/24 [115/20] via 20.1.1.1, xe2, 01:18:31
C 10.12.49.0/24 is directly connected, xe0, 01:29:05
C 20.1.1.0/24 is directly connected, xe2, 01:23:03
C 30.1.1.0/24 is directly connected, xe1, 01:23:03
i L1 40.1.1.0/24 [115/20] via 30.1.1.2, xe1, 01:18:23
i L1 50.1.1.0/24 [115/30] via 30.1.1.2, xe1, 01:18:23
i L1 60.1.1.0/24 [115/30] via 20.1.1.1, xe2, 01:18:10
C 127.0.0.0/8 is directly connected, lo, 01:35:42
PE2#
PE2#show ldp targeted-peers
IP Address Interface
2.2.2.2 xe2

PE2#
Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify
the same in FTN table.
PE2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
Code FEC FTN-ID Nhlfe-ID Tunnel-id Pri LSP-Type Out-Label Out-Intf ELC Nexthop
L> 1.1.1.1/32 7 5 - Yes LSP_DEFAULT 25606 xe2 No 20.1.1.1
L> 2.2.2.2/32 1 1 - Yes LSP_DEFAULT 3 xe2 No 20.1.1.1
L> 4.4.4.4/32 3 2 - Yes LSP_DEFAULT 3 xe1 No 30.1.1.2
L> 5.5.5.5/32 4 3 - Yes LSP_DEFAULT 25602 xe1 No 30.1.1.2
L> 6.6.6.6/32 9 7 - Yes LSP_DEFAULT 25608 xe2 No 20.1.1.1
8 - Yes LSP_DEFAULT 25605 xe1 No 30.1.1.2
L> 10.1.1.0/24 2 1 - Yes LSP_DEFAULT 3 xe2 No 20.1.1.1
L> 40.1.1.0/24 5 2 - Yes LSP_DEFAULT 3 xe1 No 30.1.1.2
L> 50.1.1.0/24 6 4 - Yes LSP_DEFAULT 25603 xe1 No 30.1.1.2
L> 60.1.1.0/24 8 6 - Yes LSP_DEFAULT 25607 xe2 No 20.1.1.1
PE2#show mpls ftn-table
Primary FTN entry with FEC: 1.1.1.1/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:40577, pkts:634, TX bytes:43113, Pushed pkts:634
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

```

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25606
Nexthop addr: 20.1.1.1 cross connect ix: 1, op code: Push
Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 20.1.1.1 cross connect ix: 2, op code: Push
Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 30.1.1.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe1, out label: 25602
Nexthop addr: 30.1.1.2 cross connect ix: 4, op code: Push
Primary FTN entry with FEC: 6.6.6.6/32, id: 9, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25608
Nexthop addr: 20.1.1.1 cross connect ix: 7, op code: Push
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25605
Nexthop addr: 30.1.1.2 cross connect ix: 7, op code: Push
Primary FTN entry with FEC: 10.1.1.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3

```

Nexthop addr: 20.1.1.1 cross connect ix: 2, op code: Push
Primary FTN entry with FEC: 40.1.1.0/24, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 30.1.1.2 cross connect ix: 3, op code: Push
Primary FTN entry with FEC: 50.1.1.0/24, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25603
Nexthop addr: 30.1.1.2 cross connect ix: 5, op code: Push
Primary FTN entry with FEC: 60.1.1.0/24, id: 8, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25607
Nexthop addr: 20.1.1.1 cross connect ix: 6, op code: Push
PE2#
PE3#show ldp session
Peer IP Address IF Name My Role State KeepAlive UpTime
5.5.5.5 xe1 Passive OPERATIONAL 30 01:47:18
3.3.3.3 xe2 Active OPERATIONAL 30 01:47:18
1.1.1.1 xe1 Active OPERATIONAL 30 01:11:17
PE3#
PE3#show clns neighbors
Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag rlfa: VRF : default
System Id Interface SNPA State Holdtime Type Protocol
PE2 xe2 5254.0087.a49f Up 8 L1 IS-IS
P2 xe1 5254.0030.e9d0 Up 7 L1 IS-IS
PE3#
Check the ISIS route installation in the ISIS table and RIB table.
PE3#show ip isis route
Codes: C - connected, E - external, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, D - discard, e - external metric
** - invalid
Tag rlfa: VRF : default

```

```
Destination Metric Next-Hop Interface Tag
```

```
L1 1.1.1.1/32 40 40.1.1.2 xe1 0
30.1.1.1 xe2 0
```

```
L1 2.2.2.2/32 30 30.1.1.1 xe2 0
```

```
L1 3.3.3.3/32 20 30.1.1.1 xe2 0
```

```
C 4.4.4.4/32 10 -- lo 0
```

```
L1 5.5.5.5/32 20 40.1.1.2 xe1 0
```

```
L1 6.6.6.6/32 30 40.1.1.2 xe1 0
```

```
L1 10.1.1.0/24 30 30.1.1.1 xe2 0
```

```
L1 20.1.1.0/24 20 30.1.1.1 xe2 0
```

```
C 30.1.1.0/24 10 -- xe2 0
```

```
C 40.1.1.0/24 10 -- xe1 0
```

```
L1 50.1.1.0/24 20 40.1.1.2 xe1 0
```

```
L1 60.1.1.0/24 30 40.1.1.2 xe1 0
```

```
PE3#
```

```
PE3#show ip route
```

```
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
```

```
O - OSPF, IA - OSPF inter area
```

```
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
```

```
E1 - OSPF external type 1, E2 - OSPF external type 2
```

```
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
```

```
ia - IS-IS inter area, E - EVPN,
```

```
v - vrf leaked
```

```
* - candidate default
```

```
IP Route Table for VRF "default"
```

```
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
```

```
K* 0.0.0.0/0 [0/0] via 10.12.49.1, xe0
```

```
i L1 1.1.1.1/32 [115/40] via 30.1.1.1, xe2, 01:49:09
```

```
[115/40] via 40.1.1.2, xe1
```

```
i L1 2.2.2.2/32 [115/30] via 30.1.1.1, xe2, 01:49:09
```

```
i L1 3.3.3.3/32 [115/20] via 30.1.1.1, xe2, 01:49:21
```

```
C 4.4.4.4/32 is directly connected, lo, 01:53:34
```

```
i L1 5.5.5.5/32 [115/20] via 40.1.1.2, xe1, 01:49:21
```

```
i L1 6.6.6.6/32 [115/30] via 40.1.1.2, xe1, 01:49:09
```

```
i L1 10.1.1.0/24 [115/30] via 30.1.1.1, xe2, 01:49:09
```

```
C 10.12.49.0/24 is directly connected, xe0, 01:58:31
```

```
i L1 20.1.1.0/24 [115/20] via 30.1.1.1, xe2, 01:49:21
```

```
C 30.1.1.0/24 is directly connected, xe2, 01:53:34
```

```
C 40.1.1.0/24 is directly connected, xe1, 01:53:34
```

```
i L1 50.1.1.0/24 [115/20] via 40.1.1.2, xe1, 01:49:21
```

```
i L1 60.1.1.0/24 [115/30] via 40.1.1.2, xe1, 01:49:09
```

```
C 127.0.0.0/8 is directly connected, lo, 02:06:35
```

```
PE3#
```

```
PE3#show ldp targeted-peers
```

```
IP Address Interface
```

```
1.1.1.1 xe2
```

```
5.5.5.5 xe1
```

```
PE3#
```

```
Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify the same in FTN table.
```



```
PE3#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
Code FEC FTN-ID Nhlfe-ID Tunnel-id Pri LSP-Type Out-Label Out-Intf ELC Nexthop
L> 1.1.1.1/32 5 3 - Yes LSP_DEFAULT 25606 xe2 No 30.1.1.1
6 - Yes LSP_DEFAULT 25600 xe1 No 40.1.1.2
L> 2.2.2.2/32 6 4 - Yes LSP_DEFAULT 25604 xe2 No 30.1.1.1
L> 3.3.3.3/32 3 2 - Yes LSP_DEFAULT 3 xe2 No 30.1.1.1
L> 5.5.5.5/32 1 1 - Yes LSP_DEFAULT 3 xe1 No 40.1.1.2
L> 6.6.6.6/32 8 7 - Yes LSP_DEFAULT 25601 xe1 No 40.1.1.2
L> 10.1.1.0/24 7 5 - Yes LSP_DEFAULT 25605 xe2 No 30.1.1.1
L> 20.1.1.0/24 4 2 - Yes LSP_DEFAULT 3 xe2 No 30.1.1.1
L> 50.1.1.0/24 2 1 - Yes LSP_DEFAULT 3 xe1 No 40.1.1.2
L> 60.1.1.0/24 9 8 - Yes LSP_DEFAULT 25603 xe1 No 40.1.1.2
PE3#
PE3#show mpls ftn-table
Primary FTN entry with FEC: 1.1.1.1/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 3
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe2, out label: 25606
Nexthop addr: 30.1.1.1 cross connect ix: 1, op code: Push
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 6
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
Nexthop addr: 40.1.1.2 cross connect ix: 1, op code: Push
Primary FTN entry with FEC: 2.2.2.2/32, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe2, out label: 25604
Nexthop addr: 30.1.1.1 cross connect ix: 4, op code: Push
Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 30.1.1.1 cross connect ix: 3, op code: Push
Primary FTN entry with FEC: 5.5.5.5/32, id: 1, row status: Active, Tunnel-Policy: N/A
```

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 40.1.1.2 cross connect ix: 2, op code: Push
Primary FTN entry with FEC: 6.6.6.6/32, id: 8, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25601
Nexthop addr: 40.1.1.2 cross connect ix: 7, op code: Push
Primary FTN entry with FEC: 10.1.1.0/24, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25605
Nexthop addr: 30.1.1.1 cross connect ix: 5, op code: Push
Primary FTN entry with FEC: 20.1.1.0/24, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 30.1.1.1 cross connect ix: 3, op code: Push
Primary FTN entry with FEC: 50.1.1.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 40.1.1.2 cross connect ix: 2, op code: Push
Primary FTN entry with FEC: 60.1.1.0/24, id: 9, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25603

```
Nexthop addr: 40.1.1.2 cross connect ix: 8, op code: Push
PE3#
P2#show ldp session
Peer IP Address IF Name My Role State KeepAlive UpTime
4.4.4.4 xe2 Active OPERATIONAL 30 01:56:09
6.6.6.6 xe1 Passive OPERATIONAL 30 01:55:26
P2#show clns neighbors
Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag rlfa: VRF : default
System Id Interface SNPA State Holdtime Type Protocol
PE3 xe2 5254.0028.c36b Up 22 L1 IS-IS
PE4 xe1 5254.00d9.5db1 Up 7 L1 IS-IS
Check the ISIS route installation in the ISIS table and RIB table.
P2#show ip isis route
Codes: C - connected, E - external, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, D - discard, e - external metric
** - invalid
Tag rlfa: VRF : default
Destination Metric Next-Hop Interface Tag
L1 1.1.1.1/32 30 50.1.1.2 xe1 0
L1 2.2.2.2/32 40 50.1.1.2 xe1 0
40.1.1.1 xe2 0
L1 3.3.3.3/32 30 40.1.1.1 xe2 0
L1 4.4.4.4/32 20 40.1.1.1 xe2 0
C 5.5.5.5/32 10 -- lo 0
L1 6.6.6.6/32 20 50.1.1.2 xe1 0
L1 10.1.1.0/24 30 50.1.1.2 xe1 0
L1 20.1.1.0/24 30 40.1.1.1 xe2 0
L1 30.1.1.0/24 20 40.1.1.1 xe2 0
C 40.1.1.0/24 10 -- xe2 0
C 50.1.1.0/24 10 -- xe1 0
L1 60.1.1.0/24 20 50.1.1.2 xe1 0
P2#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
ia - IS-IS inter area, E - EVPN,
v - vrf leaked
* - candidate default
IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
K* 0.0.0.0/0 [0/0] via 10.12.49.1, eth0
i L1 1.1.1.1/32 [115/30] via 50.1.1.2, xe1, 01:58:18
i L1 2.2.2.2/32 [115/40] via 40.1.1.1, xe2, 01:58:18
[115/40] via 50.1.1.2, xe1
i L1 3.3.3.3/32 [115/30] via 40.1.1.1, xe2, 01:58:33
```

```
i L1 4.4.4.4/32 [115/20] via 40.1.1.1, xe2, 01:58:34
C 5.5.5.5/32 is directly connected, lo, 02:02:16
i L1 6.6.6.6/32 [115/20] via 50.1.1.2, xe1, 01:58:18
i L1 10.1.1.0/24 [115/30] via 50.1.1.2, xe1, 01:58:18
C 10.12.49.0/24 is directly connected, xe0, 02:06:21
i L1 20.1.1.0/24 [115/30] via 40.1.1.1, xe2, 01:58:33
i L1 30.1.1.0/24 [115/20] via 40.1.1.1, xe2, 01:58:34
C 40.1.1.0/24 is directly connected, xe2, 02:02:16
C 50.1.1.0/24 is directly connected, xe1, 02:02:16
i L1 60.1.1.0/24 [115/20] via 50.1.1.2, xe1, 01:58:18
C 127.0.0.0/8 is directly connected, lo, 02:15:41
```

P2#show ldp targeted-peers

IP Address Interface

4.4.4.4 xe2

6.6.6.6 xe1

Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify the same in FTN table.

P2#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup

B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code FEC FTN-ID Nhlfe-ID Tunnel-id Pri LSP-Type Out-Label Out-Intf ELC Nexthop

L> 1.1.1.1/32 6 5 - Yes LSP_DEFAULT 25604 xe1 No 50.1.1.2

L> 2.2.2.2/32 5 4 - Yes LSP_DEFAULT 25604 xe2 No 40.1.1.1

6 - Yes LSP_DEFAULT 25605 xe1 No 50.1.1.2

L> 3.3.3.3/32 1 1 - Yes LSP_DEFAULT 25600 xe2 No 40.1.1.1

L> 4.4.4.4/32 2 2 - Yes LSP_DEFAULT 3 xe2 No 40.1.1.1

L> 6.6.6.6/32 7 7 - Yes LSP_DEFAULT 3 xe1 No 50.1.1.2

L> 10.1.1.0/24 8 8 - Yes LSP_DEFAULT 25606 xe1 No 50.1.1.2

L> 20.1.1.0/24 3 3 - Yes LSP_DEFAULT 25601 xe2 No 40.1.1.1

L> 30.1.1.0/24 4 2 - Yes LSP_DEFAULT 3 xe2 No 40.1.1.1

L> 60.1.1.0/24 9 7 - Yes LSP_DEFAULT 3 xe1 No 50.1.1.2

P2#show mpls ftn-table

Primary FTN entry with FEC: 1.1.1.1/32, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 5

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe1, out label: 25604

Nexthop addr: 50.1.1.2 cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 2.2.2.2/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 4

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe2, out label: 25604
Nexthop addr: 40.1.1.1 cross connect ix: 4, op code: Push
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe1, out label: 25605
Nexthop addr: 50.1.1.2 cross connect ix: 4, op code: Push
Primary FTN entry with FEC: 3.3.3.3/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: LDP, Stale: NO, out intf: xe2, out label: 25600
Nexthop addr: 40.1.1.1 cross connect ix: 1, op code: Push
Primary FTN entry with FEC: 4.4.4.4/32, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 40.1.1.1 cross connect ix: 2, op code: Push
Primary FTN entry with FEC: 6.6.6.6/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 7
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 50.1.1.2 cross connect ix: 7, op code: Push
Primary FTN entry with FEC: 10.1.1.0/24, id: 8, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25606
Nexthop addr: 50.1.1.2 cross connect ix: 8, op code: Push
Primary FTN entry with FEC: 20.1.1.0/24, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 3
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe2, out label: 25601

```

Nexthop addr: 40.1.1.1 cross connect ix: 3, op code: Push
Primary FTN entry with FEC: 30.1.1.0/24, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 40.1.1.1 cross connect ix: 2, op code: Push
Primary FTN entry with FEC: 60.1.1.0/24, id: 9, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 7
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 50.1.1.2 cross connect ix: 7, op code: Push
PE4#show ldp session
Peer IP Address IF Name My Role State KeepAlive UpTime
5.5.5.5 xe2 Active OPERATIONAL 30 02:03:56
1.1.1.1 xe1 Active OPERATIONAL 30 02:04:24
PE4#show clns neighbors
Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag rlfa: VRF : default
System Id Interface SNPA State Holdtime Type Protocol
P2 xe2 5254.0043.7db3 Up 21 L1 IS-IS

PE1 xe1 5254.006e.5166 Up 19 L1 IS-IS
Verify ISIS LFA and RLFA backup computed paths for Primary Paths
PE4#show ip isis route
Codes: C - connected, E - external, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, D - discard, e - external metric
** - invalid
Tag rlfa: VRF : default
Destination Metric Next-Hop Interface Tag
L1 1.1.1.1/32 20 60.1.1.2 xe1 0
L1 2.2.2.2/32 30 60.1.1.2 xe1 0
L1 3.3.3.3/32 40 50.1.1.1 xe2 0
60.1.1.2 xe1 0
L1 4.4.4.4/32 30 50.1.1.1 xe2 0
L1 5.5.5.5/32 20 50.1.1.1 xe2 0
C 6.6.6.6/32 10 -- lo 0
L1 10.1.1.0/24 20 60.1.1.2 xe1 0
L1 20.1.1.0/24 30 60.1.1.2 xe1 0
L1 30.1.1.0/24 30 50.1.1.1 xe2 0
L1 40.1.1.0/24 20 50.1.1.1 xe2 0
C 50.1.1.0/24 10 -- xe2 0

```

```

C 60.1.1.0/24 10 -- xe1 0
PE4#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
ia - IS-IS inter area, E - EVPN,
v - vrf leaked
* - candidate default
IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
K* 0.0.0.0/0 [0/0] via 10.12.49.1, xe0
i L1 1.1.1.1/32 [115/20] via 60.1.1.2, xe1, 02:05:57
i L1 2.2.2.2/32 [115/30] via 60.1.1.2, xe1, 02:05:40
i L1 3.3.3.3/32 [115/40] via 60.1.1.2, xe1, 02:05:40
[115/40] via 50.1.1.1, xe2
i L1 4.4.4.4/32 [115/30] via 50.1.1.1, xe2, 02:05:40
i L1 5.5.5.5/32 [115/20] via 50.1.1.1, xe2, 02:05:40
C 6.6.6.6/32 is directly connected, lo, 02:09:10
i L1 10.1.1.0/24 [115/20] via 60.1.1.2, xe1, 02:05:57
C 10.12.49.0/24 is directly connected, xe0, 02:13:17
i L1 20.1.1.0/24 [115/30] via 60.1.1.2, xe1, 02:05:40
i L1 30.1.1.0/24 [115/30] via 50.1.1.1, xe2, 02:05:40
i L1 40.1.1.0/24 [115/20] via 50.1.1.1, xe2, 02:05:40
C 50.1.1.0/24 is directly connected, xe2, 02:09:10
C 60.1.1.0/24 is directly connected, xe1, 02:09:10
C 127.0.0.0/8 is directly connected, lo, 02:23:07
PE4#show ldp targeted-peers
IP Address Interface
1.1.1.1 xe1
5.5.5.5 xe2
Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify
the same in FTN table.
PE4#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
Code FEC FTN-ID Nhlfe-ID Tunnel-id Pri LSP-Type Out-Label Out-Intf ELC Nexthop
L> 1.1.1.1/32 1 1 - Yes LSP_DEFAULT 3 xe1 No 60.1.1.2
L> 2.2.2.2/32 3 2 - Yes LSP_DEFAULT 25604 xe1 No 60.1.1.2
L> 3.3.3.3/32 4 3 - Yes LSP_DEFAULT 25605 xe1 No 60.1.1.2
5 - Yes LSP_DEFAULT 25604 xe2 No 50.1.1.1
L> 4.4.4.4/32 6 6 - Yes LSP_DEFAULT 25605 xe2 No 50.1.1.1
L> 5.5.5.5/32 7 7 - Yes LSP_DEFAULT 3 xe2 No 50.1.1.1
L> 10.1.1.0/24 2 1 - Yes LSP_DEFAULT 3 xe1 No 60.1.1.2
L> 20.1.1.0/24 5 4 - Yes LSP_DEFAULT 25606 xe1 No 60.1.1.2
L> 30.1.1.0/24 8 8 - Yes LSP_DEFAULT 25607 xe2 No 50.1.1.1
L> 40.1.1.0/24 9 7 - Yes LSP_DEFAULT 3 xe2 No 50.1.1.1
PE4#show mpls ftn-table

```

Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 60.1.1.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xe1, out label: 25604
Nexthop addr: 60.1.1.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 3
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe1, out label: 25605
Nexthop addr: 60.1.1.2 cross connect ix: 3, op code: Push
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25604
Nexthop addr: 50.1.1.1 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:92403, pkts:1494, TX bytes:98379, Pushed pkts:1494
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25605
Nexthop addr: 50.1.1.1 cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 7
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 50.1.1.1 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 10.1.1.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 60.1.1.2 cross connect ix: 1, op code: Push
Primary FTN entry with FEC: 20.1.1.0/24, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25606
Nexthop addr: 60.1.1.2 cross connect ix: 4, op code: Push
Primary FTN entry with FEC: 30.1.1.0/24, id: 8, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe2, out label: 25607
Nexthop addr: 50.1.1.1 cross connect ix: 8, op code: Push
Primary FTN entry with FEC: 40.1.1.0/24, id: 9, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 7
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 50.1.1.1 cross connect ix: 7, op code: Push

CHAPTER 7 LDP MD5 Password For Auto Targeted Sessions

A basic mechanism using Loop-Free Alternates (LFAs) is described in RFC5286 that provides good repair coverage in many topologies, especially those that are highly meshed.

However, some topologies, notably ring-based topologies, are not well protected by LFAs alone. This is because there is no neighbor of the Point of Local Repair (PLR) that has a cost to the destination via a path that does not traverse the failure that is cheaper than the cost to the destination via the failure.

When LDP RLFA creates a virtual path in the network to provide an alternate path, it uses MPLS labels distributed by a targeted session between the local node and the PLR (PQ node), the session is established without any MD5 Password protection mechanism, as it is only available for non-automatic targeted sessions. A set of configurable options will be provided to associate MD5 passwords to the auto-targeted sessions.

Topology

Figure 7-8 shows the configuration required to enable the RLFA feature.

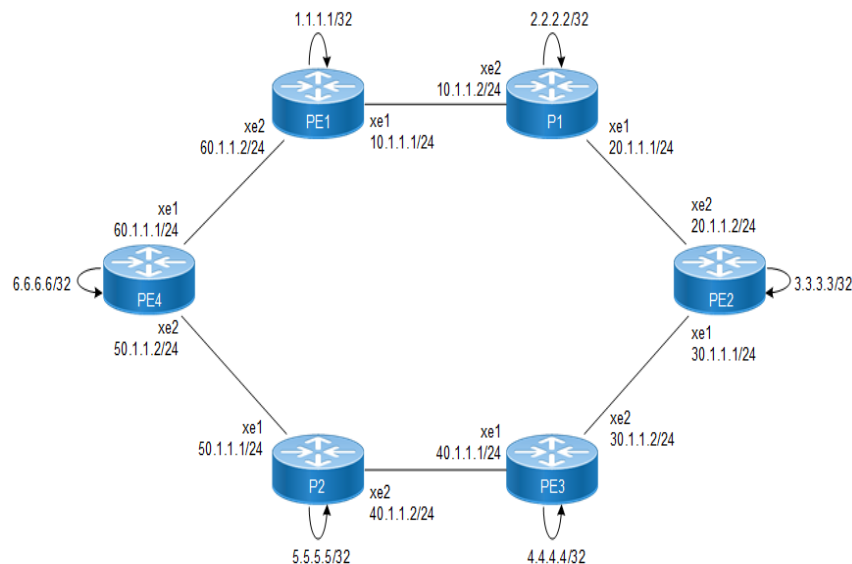


Figure 7-8: RLFA Topology

Configuration

RTR 1

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#neighbor auto-targeted auth md5 password plain-text test2	Configure md5 authentication for auto-targeted peers

(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#router rsvp	Enable RSPVP
(config-router)#srlg-disjoint forced	Configure srlg to enable mpls-TE
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure the ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#mpls traffic-eng srlg 11	Enable Mpls-TE
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 60.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#mpls traffic-eng srlg 11	Enable mpls-TE
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 1.1.1.1/32 secondary	Configure the IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Create an ospf instance
(config-router)# ospf router-id 1.1.1.1	Configure router id
(config-router)# bfd all-interfaces	Configure bfd
(config-router)# timers spf exp 50 50	Configure the ospf timers
(config-router)# timers throttle lsa all 0 1 1	Configure the ospf timer lsa throttle
(config-router)# timers lsa arrival 1	Configure the ospf timer lsa arrival
(config-router)# fast-reroute per-prefix remote-lfa area 0.0.0.0 tunnel mpls-ldp	. Configure Remote LFA to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
(config-router)# network 1.1.1.1/32 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 60.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes

(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#end	Exit router mode.
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally

RTR 2

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#neighbor auto-targeted auth md5 password plain-text test2	Configure md5 authentication for auto-targeted peers
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#router rsvp	Enable RSPVP
(config-router)#srlg-disjoint forced	Configure srlg to enable mpls-TE
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 10.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure the ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#mpls traffic-eng srlg 11	Enable Mpls-TE
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 20.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#mpls traffic-eng srlg 11	Enable mpls-TE
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Configure the IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Create an ospf instance
(config-router)# ospf router-id 2.2.2.2	Configure router id

(config-router)# bfd all-interfaces	Configure bfd
(config-router)# timers spf exp 50 50	Configure the ospf timers
(config-router)# timers throttle lsa all 0 1 1	Configure the ospf timer lsa throttle
(config-router)# timers lsa arrival 1	Configure the ospf timer lsa arrival
(config-router)# network 2.2.2.2/32 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 20.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit router mode.

RTR 3

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#neighbor auto-targeted auth md5 password plain-text test2	Configure md5 authentication for auto-targeted peers
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#router rsvp	Enable RSPVP
(config-router)#srlg-disjoint forced	Configure srlg to enable mpls-TE
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 20.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure the ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#mpls traffic-eng srlg 11	Enable Mpls-TE
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 30.1.1.1/24	Configure the IP address of the interface.

(config-if)#ip ospf cost 10	Configure ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#mpls traffic-eng srlg 11	Enable mpls-TE
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 3.3.3.3/32 secondary	Configure the IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Create an ospf instance
(config-router)# ospf router-id 3.3.3.3	Configure router id
(config-router)# bfd all-interfaces	Configure bfd
(config-router)# timers spf exp 50 50	Configure the ospf timers
(config-router)# timers throttle lsa all 0 1 1	Configure the ospf timer lsa throttle
(config-router)# timers lsa arrival 1	Configure the ospf timer lsa arrival
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 20.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 30.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit router mode.

RTR 4

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#neighbor auto-targeted auth md5 password plain-text test2	Configure md5 authentication for auto-targeted peers
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#router rsvp	Enable RSVP
(config-router)#srlg-disjoint forced	Configure srlg to enable mpls-TE

(config-router)#commit	Commit the candidate configuration to the running configuration
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 30.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure the ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#mpls traffic-eng srlg 11	Enable Mpls-TE
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 40.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#mpls traffic-eng srlg 11	Enable mpls-TE
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 4.4.4.4/32 secondary	Configure the IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Create an ospf instance
(config-router)# ospf router-id 4.4.4.4	Configure router id
(config-router)# bfd all-interfaces	Configure bfd
(config-router)# timers spf exp 50 50	Configure the ospf timers
(config-router)# timers throttle lsa all 0 1 1	Configure the ospf timer lsa throttle
(config-router)# timers lsa arrival 1	Configure the ospf timer lsa arrival
(config-router)# network 4.4.4.4/32 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 40.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 30.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit router mode.

RTR 5

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#neighbor auto-targeted auth md5 password plain-text test2	Configure md5 authentication for auto-targeted peers
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#router rsvp	Enable RSPVP
(config-router)#srlg-disjoint forced	Configure srlg to enable mpls-TE
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 40.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure the ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#mpls traffic-eng srlg 11	Enable Mpls-TE
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 50.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#mpls traffic-eng srlg 11	Enable mpls-TE
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 5.5.5.5/32 secondary	Configure the IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Create an ospf instance
(config-router)# ospf router-id 5.5.5.5	Configure router id
(config-router)# bfd all-interfaces	Configure bfd
(config-router)# timers spf exp 50 50	Configure the ospf timers
(config-router)# timers throttle lsa all 0 1 1	Configure the ospf timer lsa throttle
(config-router)# timers lsa arrival 1	Configure the ospf timer lsa arrival

(config-router)# network 5.5.5.5/32 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 50.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 40.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit router mode.

RTR 6

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#neighbor auto-targeted auth md5 password plain-text test2	Configure md5 authentication for auto-targeted peers
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#router rsvp	Enable RSPVP
(config-router)#srlg-disjoint forced	Configure srlg to enable mpls-TE
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 50.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure the ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#mpls traffic-eng srlg 11	Enable Mpls-TE
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 60.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#mpls traffic-eng srlg 11	Enable mpls-TE
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface

(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 6.6.6.6/32 secondary	Configure the IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Create an ospf instance
(config-router)# ospf router-id 6.6.6.6	Configure router id
(config-router)# bfd all-interfaces	Configure bfd
(config-router)# timers spf exp 50 50	Configure the ospf timers
(config-router)# timers throttle lsa all 0 1 1	Configure the ospf timer lsa throttle
(config-router)# timers lsa arrival 1	Configure the ospf timer lsa arrival
(config-router)# network 6.6.6.6/32 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 50.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 60.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit router mode.

Validation

RTR 1

Check LDP neighborhood before enabling RLFA

Rtr1#sh ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	xe20	Passive	OPERATIONAL	30	00:02:43
6.6.6.6	ge10	Passive	OPERATIONAL	30	00:00:30

Check the output of "show ip ospf neighbors" to verify that ospf adjacency is up.

Rtr1#sh ip ospf neighbor

Total number of full neighbors: 2

OSPF process 1 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface
2.2.2.2	1	Full/Backup	00:00:39	10.1.1.2	xe20

0

```
6.6.6.6          1    Full/DR          00:00:35    60.1.1.2    ge10
0
```

Rtr1#

Check the ospf route installation in the ospf table and RIB table.

Rtr1#sh ip route

Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
 O - OSPF, IA - OSPF inter area
 N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
 E1 - OSPF external type 1, E2 - OSPF external type 2
 i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
 ia - IS-IS inter area, E - EVPN,
 v - vrf leaked
 * - candidate default

IP Route Table for VRF "default"

```
C      1.1.1.1/32 is directly connected, lo, 00:37:05
O      2.2.2.2/32 [110/11] via 10.1.1.2, xe20, 00:04:49
O      3.3.3.3/32 [110/21] via 10.1.1.2, xe20, 00:04:49
O      4.4.4.4/32 [110/31] via 60.1.1.2, ge10, 00:04:49
      [110/31] via 10.1.1.2, xe20
O      5.5.5.5/32 [110/21] via 60.1.1.2, ge10, 00:02:29
O      6.6.6.6/32 [110/11] via 60.1.1.2, ge10, 00:02:29
C      10.1.1.0/24 is directly connected, xe20, 00:33:59
O      20.1.1.0/24 [110/20] via 10.1.1.2, xe20, 00:04:49
O      30.1.1.0/24 [110/30] via 10.1.1.2, xe20, 00:04:49
O      40.1.1.0/24 [110/30] via 60.1.1.2, ge10, 00:02:29
O      50.1.1.0/24 [110/20] via 60.1.1.2, ge10, 00:02:29
C      60.1.1.0/24 is directly connected, ge10, 00:02:36
C      127.0.0.0/8 is directly connected, lo, 00:45:19
```

Gateway of last resort is not set

Rtr1#

Rtr1#sh ip ospf route

OSPF process 1:

Codes: C - connected, D - Discard, O - OSPF, IA - OSPF inter area
 N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
 E1 - OSPF external type 1, E2 - OSPF external type 2
 OSPF LFA attributes:
 P - Primary, SP - Secondary-Path, LP - Link Protecting,
 NP - Node Protecting, BID - Broadcast Link Protecting
 DP - Downstream Protecting

```
C 1.1.1.1/32 [1] is directly connected, lo, Area 0.0.0.0
O 2.2.2.2/32 [11] via 10.1.1.2, xe20, Area 0.0.0.0
O 3.3.3.3/32 [21] via 10.1.1.2, xe20, Area 0.0.0.0
O 4.4.4.4/32 [31] via 10.1.1.2, xe20, Area 0.0.0.0
      via 60.1.1.2, ge10, Area 0.0.0.0
O 5.5.5.5/32 [21] via 60.1.1.2, ge10, Area 0.0.0.0
O 6.6.6.6/32 [11] via 60.1.1.2, ge10, Area 0.0.0.0
```

```

C 10.1.1.0/24 [10] is directly connected, xe20, Area 0.0.0.0
O 20.1.1.0/24 [20] via 10.1.1.2, xe20, Area 0.0.0.0
O 30.1.1.0/24 [30] via 10.1.1.2, xe20, Area 0.0.0.0
O 40.1.1.0/24 [30] via 60.1.1.2, ge10, Area 0.0.0.0
O 50.1.1.0/24 [20] via 60.1.1.2, ge10, Area 0.0.0.0
C 60.1.1.0/24 [10] is directly connected, ge10, Area 0.0.0.0
Rtr1#

```

Verify ospf LFA and RLFA backup computed paths for Primary Paths

```
Rtr1#sh ip ospf route fast-reroute
```

OSPF process 1:

Codes: C - connected, D - Discard, O - OSPF, IA - OSPF inter area

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

E1 - OSPF external type 1, E2 - OSPF external type 2

OSPF LFA attributes:

P - Primary, SP - Secondary-Path, LP - Link Protecting,

NP - Node Protecting, BID - Broadcast Link Protecting

DP - Downstream Protecting

```

O 2.2.2.2/32 [11] via 10.1.1.2, xe20, Area 0.0.0.0
    Remote FRR path:
    via 4.4.4.4, via 60.1.1.2, ge10, Area 0.0.0.0
    Attributes: Metric: [51] ,LP
O 3.3.3.3/32 [21] via 10.1.1.2, xe20, Area 0.0.0.0
    Remote FRR path:
    via 4.4.4.4, via 60.1.1.2, ge10, Area 0.0.0.0
    Attributes: Metric: [41] ,LP ,NP ,DP
O 4.4.4.4/32 [31] via 10.1.1.2, xe20, Area 0.0.0.0
    Backup path:
    via 60.1.1.2, ge10, Area 0.0.0.0
    Attributes: Metric: [31] ,P ,NP ,BID ,DP
    via 60.1.1.2, ge10, Area 0.0.0.0
    Backup path:
    via 10.1.1.2, xe20, Area 0.0.0.0
    Attributes: Metric: [31] ,P ,NP ,BID ,DP
O 5.5.5.5/32 [21] via 60.1.1.2, ge10, Area 0.0.0.0
    Remote FRR path:
    via 4.4.4.4, via 10.1.1.2, xe20, Area 0.0.0.0
    Attributes: Metric: [41] ,LP ,NP ,DP
O 6.6.6.6/32 [11] via 60.1.1.2, ge10, Area 0.0.0.0
    Remote FRR path:
    via 4.4.4.4, via 10.1.1.2, xe20, Area 0.0.0.0
    Attributes: Metric: [51] ,LP
O 20.1.1.0/24 [20] via 10.1.1.2, xe20, Area 0.0.0.0
    Remote FRR path:
    via 4.4.4.4, via 60.1.1.2, ge10, Area 0.0.0.0
    Attributes: Metric: [50] ,LP ,NP
O 30.1.1.0/24 [30] via 10.1.1.2, xe20, Area 0.0.0.0
    Backup path:

```

```

        via 60.1.1.2, ge10, Area 0.0.0.0
        Attributes: Metric: [40] ,SP ,NP ,BID
O  40.1.1.0/24 [30] via 60.1.1.2, ge10, Area 0.0.0.0
    Backup path:
        via 10.1.1.2, xe20, Area 0.0.0.0
        Attributes: Metric: [40] ,SP ,NP ,BID
O  50.1.1.0/24 [20] via 60.1.1.2, ge10, Area 0.0.0.0
    Remote FRR path:
        via 4.4.4.4, via 10.1.1.2, xe20, Area 0.0.0.0
        Attributes: Metric: [50] ,LP ,NP
Rtr1#

```

Verify PQ node which is near to source is selected and Target-LDP session is established with PQ node using below commands

```

Rtr1#sh ldp session
Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
2.2.2.2              xe20       Passive    OPERATIONAL 30         00:07:29
6.6.6.6              ge10       Passive    OPERATIONAL 30         00:05:16
4.4.4.4              xe20       Passive    OPERATIONAL 30         00:05:04

```

To verify which password is enabled

```

Rtr1#sh ldp session 4.4.4.4
Session state       : OPERATIONAL
Session role        : Passive
TCP Connection      : Established
IP Address for TCP  : 4.4.4.4
Interface being used : xe23
Peer LDP ID         : 4.4.4.4:0
Peer LDP Password   : test2
Authentication type  : MD5
Adjacencies         : 4.4.4.4
Advertisement mode   : Downstream Unsolicited
Label retention mode : Liberal
Graceful Restart    : Not Capable
Keepalive Timeout    : 30
Reconnect Interval  : 15
Address List received : 4.4.4.4
                     40.1.1.2
                     70.1.1.2

Received Labels :      Fec          Label          Maps To
                  IPV4:70.1.1.0/24    impl-null      none
                  IPV4:60.1.1.0/24    35218          none
                  IPV4:50.1.1.0/24    35216          none
                  IPV4:40.1.1.0/24    impl-null      none
                  IPV4:20.1.1.0/24    35214          none
                  IPV4:10.1.1.0/24    35212          none
                  IPV4:6.6.6.6/32     35209          none
                  IPV4:5.5.5.5/32     35207          none
                  IPV4:4.4.4.4/32     impl-null      none

```

Sent Labels :	IPV4:3.3.3.3/32	35205	none
	IPV4:2.2.2.2/32	35203	none
	IPV4:1.1.1.1/32	35202	none
	Fec	Label	Maps To
	IPV4:70.1.1.0/24	35218	34563
	IPV4:70.1.1.0/24	35218	34567
	IPV4:60.1.1.0/24	35217	34564
	IPV4:60.1.1.0/24	35217	34562
	IPV4:50.1.1.0/24	impl-null	none
	IPV4:40.1.1.0/24	35216	impl-null
	IPV4:20.1.1.0/24	35215	impl-null
	IPV4:10.1.1.0/24	impl-null	none
	IPV4:6.6.6.6/32	35214	34565
	IPV4:6.6.6.6/32	35214	34561
	IPV4:5.5.5.5/32	35213	impl-null
	IPV4:4.4.4.4/32	35212	34560
	IPV4:3.3.3.3/32	35211	34561
	IPV4:2.2.2.2/32	35210	impl-null
	IPV4:1.1.1.1/32	impl-null	none

Verify that Primary and Backup FTN's are installed with labels in LDP RLFA route table

Rtr1#sh ldp rfa-routes

Codes: p - stale rLFA route

Fec	Primary-NH	Backup-NH	rLFA-Addr	Out-Intf	Outer-label
Inner-label	Owner				
2.2.2.2	10.1.1.2	60.1.1.2	4.4.4.4	ge10	24964
ospf					
3.3.3.3	10.1.1.2	60.1.1.2	4.4.4.4	ge10	24964
ospf					
5.5.5.5	60.1.1.2	10.1.1.2	4.4.4.4	xe20	24963
ospf					
6.6.6.6	60.1.1.2	10.1.1.2	4.4.4.4	xe20	24963
ospf					
20.1.1.0	10.1.1.2	60.1.1.2	4.4.4.4	ge10	24964
ospf					
50.1.1.0	60.1.1.2	10.1.1.2	4.4.4.4	xe20	24963
ospf					

Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify the same in FTN table.

Rtr1#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
 B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
 (m) - FTN mapped over multipath transport

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					

```

L> 2.2.2.2/32 1 2 - Yes LSP_DEFAULT 3
xe20 No 10.1.1.2
ge10 No 4.4.4.4 23 - No LSP_DEFAULT 24969
60.1.1.2 ,label 24964) (via
L> 3.3.3.3/32 2 4 - Yes LSP_DEFAULT 24962
xe20 No 10.1.1.2
ge10 No 4.4.4.4 24 - No LSP_DEFAULT 24970
60.1.1.2 ,label 24964) (via
L> 4.4.4.4/32 3 6 - Yes LSP_DEFAULT 24963
xe20 No 10.1.1.2
ge10 No 60.1.1.2 7 - No LSP_DEFAULT 24964
ge10 No 60.1.1.2 7 - Yes LSP_DEFAULT 24964
xe20 No 10.1.1.2 5 - No LSP_DEFAULT 24963
L> 5.5.5.5/32 4 10 - Yes LSP_DEFAULT 24965
ge10 No 60.1.1.2
xe20 No 4.4.4.4 25 - No LSP_DEFAULT 24971
10.1.1.2 ,label 24963) (via
L> 6.6.6.6/32 5 15 - Yes LSP_DEFAULT 3
ge10 No 60.1.1.2
xe20 No 4.4.4.4 26 - No LSP_DEFAULT 24972
10.1.1.2 ,label 24963) (via
L> 20.1.1.0/24 6 11 - Yes LSP_DEFAULT 3
xe20 No 10.1.1.2
ge10 No 4.4.4.4 27 - No LSP_DEFAULT 24974
60.1.1.2 ,label 24964) (via
L> 30.1.1.0/24 7 13 - Yes LSP_DEFAULT 24966
xe20 No 10.1.1.2
ge10 No 60.1.1.2 16 - No LSP_DEFAULT 24966
L> 40.1.1.0/24 8 19 - Yes LSP_DEFAULT 24967
ge10 No 60.1.1.2
xe20 No 10.1.1.2 20 - No LSP_DEFAULT 24967
L> 50.1.1.0/24 9 22 - Yes LSP_DEFAULT 3
ge10 No 60.1.1.2
xe20 No 4.4.4.4 28 - No LSP_DEFAULT 24975
10.1.1.2 ,label 24963) (via
Rtrl#sh mpls ftn-table
Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

```

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe20, out label: 3
Nexthop addr: 10.1.1.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 23
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 23, owner: LDP, Stale: NO, out intf: ge10, out label: 24969
Nexthop addr: 4.4.4.4 cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 3.3.3.3/32, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 3
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe20, out label: 24962
Nexthop addr: 10.1.1.2 cross connect ix: 2, op code: Push

Backup Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 24
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 24, owner: LDP, Stale: NO, out intf: ge10, out label: 24970
Nexthop addr: 4.4.4.4 cross connect ix: 11, op code: Push

Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe20, out label: 24963
Nexthop addr: 10.1.1.2 cross connect ix: 3, op code: Push

Backup Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: ge10, out label: 24964
Nexthop addr: 60.1.1.2 cross connect ix: 3, op code: Push

Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: ge10, out label: 24964
Nexthop addr: 60.1.1.2 cross connect ix: 3, op code: Push

Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe20, out label: 24963
Nexthop addr: 10.1.1.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 9
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: ge10, out label: 24965
Nexthop addr: 60.1.1.2 cross connect ix: 5, op code: Push

Backup Cross connect ix: 13, in intf: - in label: 0 out-segment ix: 25
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 25, owner: LDP, Stale: NO, out intf: xe20, out label: 24971
Nexthop addr: 4.4.4.4 cross connect ix: 13, op code: Push

Primary FTN entry with FEC: 6.6.6.6/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 14
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 14, owner: N/A, Stale: NO, out intf: ge10, out label: 3
Nexthop addr: 60.1.1.2 cross connect ix: 7, op code: Push

Backup Cross connect ix: 15, in intf: - in label: 0 out-segment ix: 26
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 26, owner: LDP, Stale: NO, out intf: xe20, out label: 24972
Nexthop addr: 4.4.4.4 cross connect ix: 15, op code: Push

Primary FTN entry with FEC: 20.1.1.0/24, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe20, out label: 3
Nexthop addr: 10.1.1.2 cross connect ix: 1, op code: Push

Backup Cross connect ix: 17, in intf: - in label: 0 out-segment ix: 27
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 27, owner: LDP, Stale: NO, out intf: ge10, out label: 24974
Nexthop addr: 4.4.4.4 cross connect ix: 17, op code: Push

Primary FTN entry with FEC: 30.1.1.0/24, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 12
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe20, out label: 24966
 Nexthop addr: 10.1.1.2 cross connect ix: 6, op code: Push

Backup Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 16

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 16, owner: LDP, Stale: NO, out intf: ge10, out label: 24966
 Nexthop addr: 60.1.1.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 40.1.1.0/24, id: 8, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 18

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 18, owner: LDP, Stale: NO, out intf: ge10, out label: 24967
 Nexthop addr: 60.1.1.2 cross connect ix: 8, op code: Push

Backup Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 20

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 20, owner: LDP, Stale: NO, out intf: xe20, out label: 24967
 Nexthop addr: 10.1.1.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 50.1.1.0/24, id: 9, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0

Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 14

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 14, owner: N/A, Stale: NO, out intf: ge10, out label: 3
 Nexthop addr: 60.1.1.2 cross connect ix: 7, op code: Push

Backup Cross connect ix: 19, in intf: - in label: 0 out-segment ix: 28

Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 28, owner: LDP, Stale: NO, out intf: xe20, out label: 24975
 Nexthop addr: 4.4.4.4 cross connect ix: 19, op code: Push

Rtrl#

Note: The following CLI will be used to configure different types of MD5 authentication.

- To configure dedicated MD5 password to a neighbor (under router ldp):

```
neighbor A.B.C.D auth md5 password (plain-text|encrypt) WORD
```

 The same should be configured on neighbour A.B.C.D.
- To set password for all LDP neighbors (under router ldp):

```
neighbor all auth md5 password (plain-text|encrypt) WORD
```
- To exclude password for a neighbor (under router ldp)

```
neighbor A.B.C.D auth md5 password exclude
```

- To set password for auto-targeted sessions (under router ldp):
 neighbor auto-targeted auth md5 password (plain-text|encrypt) WORD
- To create session group (under router ldp)
 session-group name WORD
- To set password for the session group (under session group)
 auth md5 password (plain-text|encrypt) WORD
- To add neighbors in the group (under session group)
 neighbor prefix-list <prefix-list-name>

CHAPTER 8 LDP ECMP Configuration

This chapter contains configurations of LDP ECMP detailed tests that are used to verify the functionality of LDP ECMP (Equal-cost multipath).

Topology

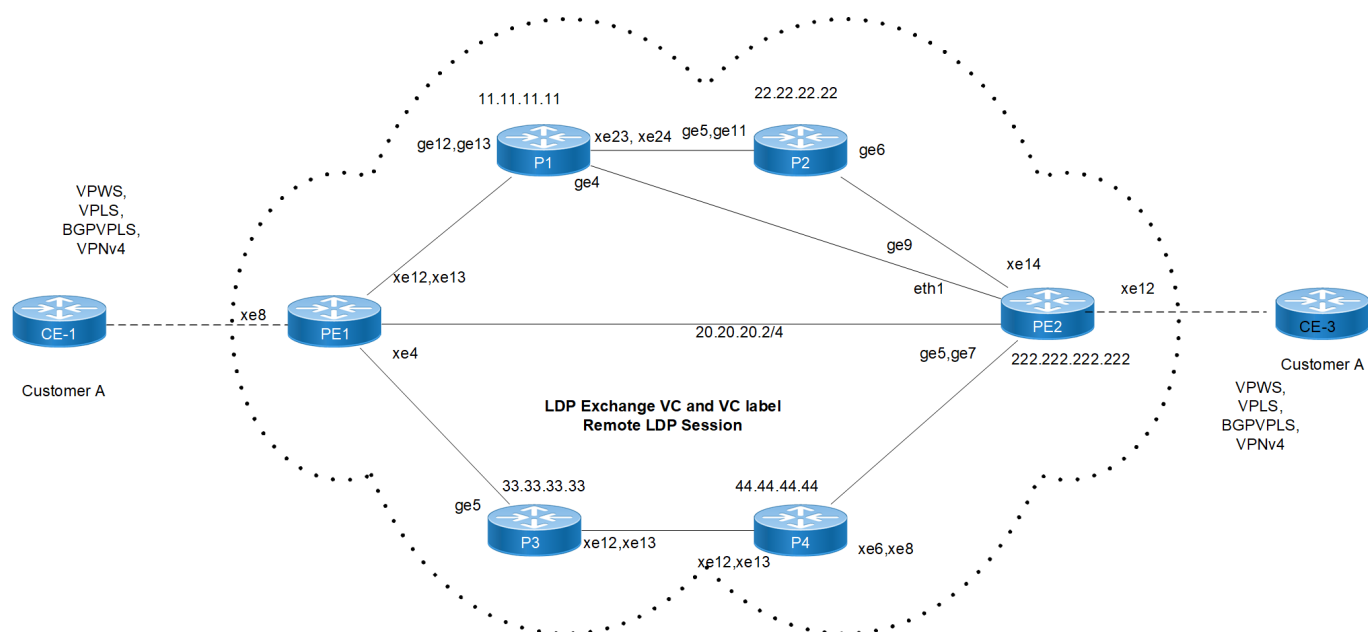


Figure 8-9: LDP-ECMP configuration topology

Configurations

PE-1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 111.111.111.111/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 111.111.111.111	Configure Router-id
(config-router)#targeted-peer ipv4 222.222.222.222	Configuring targeted LDP sessions to PE-2

(config-router)#explicit-null	Configure explicit-null.
(config-router)#entropy-label-capability	Enable entropy capability in ldp
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)#transport-address ipv4 111.111.111.111	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface xe13	Enter interface mode
(config-if)#speed 1g	Configure interface speed to 1g
(config-if)#ip address 10.0.1.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po1000	Enter the Interface mode for po1000
(config-if)#exit	Exit interface mode
(config)#interface po1000.1000	Enter interface mode for po1000.1000
(config-if)#encapsulation dot1q 1000	Configure encapsulation under a subinterface
(config-if)#ip address 10.0.0.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe4	Enter interface mode
(config-if)#speed 1g	Configure interface speed to 1g
(config-if)#ip address 16.0.0.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe4.1001	Enter interface mode
(config-if)#encapsulation dot1q 1001	Configure encapsulation under a subinterface
(config-if)#ip address 16.0.1.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration

(config-if)#exit	Exit interface mode
(config-if)#interface xe12	Enter interface mode
(config-if)#speed 1g	Configure interface speed to 1g
(config-if)#channel-group 1000 mode active	Moving interface to Dynamic LAG
(config-if)#exit	Exit interface mode
(config)#ip vrf l3vpnvrf300	IP VRF config with name l3vpnvrf300
(config-vrf)#rd 300:1	Route-distinguisher value
(config-vrf)#route-target both 300:1	Route target value
(config-vrf)#exit	Exit to config mode
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 111.111.111.111	Configure ospf Router-id
(config-router)#network 10.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 16.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 16.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 111.111.111.111/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#router bgp 100	Configure router bgp in AS 100
(config-router)#bgp router-id 111.111.111.111	Configure BGP router ID
(config-router)#neighbor 222.222.222.222 remote-as 100	Configure neighbor in remote-as 100
(config-router)#neighbor 222.222.222.222 update-source lo	Configure neighbor with update-source loopback
(config-router)#address-family vpnv4 unicast	Enter VPNv4 Address family mode
(config-router-af)#neighbor 222.222.222.222 activate	mode Activate VPNv4 neighbor
(config-router-af)#exit-address-family	Exit from Address Family configuration
(config-router)#address-family l2vpn vpls	Enter vpls Address family mode
(config-router-af)#neighbor 222.222.222.222 activate	mode Activate vpls neighbor
(config-router-af)#exit-address-family	Exit from Address Family configuration
(config-router)#address-family vrf l3vpnvrf300	Configure VRF address family
(config-router-af)#redistribute connected	Redistribute connected addresses
(config-router-af)#exit-address-family	Exit from Address Family configuration
(config-router)#exit	Exit from router mode

(config)#mpls vplsldp100 100	Configuring VPLS instance with name and VPLS ID
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance
(config-vpls-sig)# vpls-peer 222.222.222.222	Configuring VPLS mesh peers
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config)#mpls l2-circuit VPWS400 400 222.222.222.222	Configuring VPWS instance with name and VPWS ID
(config)#mpls vpls vplsbgp200 200	Configuring VPLS instance with name and VPLS ID
(config-vpls)#signaling bgp	Enabling LDP signaling for the VPLS instance
(config-vpls-sig)#ve-id 200	Configure VE ID, which is mandatory for BGP VPLS,
otherwise, signaling does not take place. VE ID should be	
unique per VPLS instance	
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config-if)#interface xe8.100 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls vplsldp100	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#exit	Exit from access mode
(config-if)#interface xe8.400 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 400	Configure encapsulation under a subinterface
(config-if)#access-if-vpws	Access VPWS under sub interface
(config-acc-if-vpws)#mpls-vpws VPWS400	Associating the VPWS Instance to the attachment circuit interface.
(config-acc-if-vpws)#exit	Exit from access mode
(config-if)#interface xe8.200 switchport	Enter sub interface mode
(config-if)#split-horizon group access1	Configure split-horizon group on sub-interface
(config-if)#split-horizon group access1	Configure split-horizon group on sub-interface
(config-if)#encapsulation dot1q 200	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls vplsbgp200	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#exit	Exit from access mode
(config-if)#interface xe8.300	Enter sub interface mode
(config-if)#encapsulation dot1q 300	Configure encapsulation under a subinterface
(config-if)#ip vrf forwarding l3vpnvrf300	Attaching xe8.300 to as part of l3vpnvrf300
(config-if)#ip address 110.110.110.1/24	Configure the IP address of the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the configuration
(config)#end	Return to privilege mode

P1

#configure terminal	Enter Configure mode.
(config)#mpls ilm-ecmp	Enable ilm ecmp
(config)#interface lo	Enter interface mode
(config-if)#ip address 11.11.11.11/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 11.11.11.11	Configure Router-id
(config-router)#transport-address ipv4 11.11.11.11	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface ge13	Enter interface mode
(config-if)#ip address 10.0.1.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po1000	Enter the Interface mode for po1000
(config-if)#exit	Exit interface mode
(config)#interface po1000.1000	Enter interface mode for po1000.1000
(config-if)#encapsulation dot1q 1000	Configure encapsulation under a subinterface
(config-if)#ip address 10.0.0.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po2000	Enter the Interface mode for po2000
(config-if)#exit	Exit interface mode
(config)#interface po2000.100	Enter interface mode for po2000.100
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#ip address 11.0.0.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface

(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface ge4	Enter interface mode
(config-if)#ip address 9.0.0.10/24	Configure IP address on interface
(config-if)#ip ospf cost 20	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface ge12	Enter interface mode
(config-if)#channel-group 1000 mode active	Moving interface to Dynamic LAG
(config)#interface xe23	Enter interface mode
(config-if)#channel-group 2000 mode active	Moving interface to Dynamic LAG
(config-if)#speed 1g	Configure speed 1g
(config)#interface xe24	Enter interface mode
(config-if)#channel-group 2000 mode active	Moving interface to Dynamic LAG
(config-if)#speed 1g	Configure speed 1g
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 11.11.11.11	Configure ospf Router-id
(config-router)#network 10.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 11.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 9.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 11.11.11.11/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#exit	Exit from router mode
(config)#commit	Commit the transaction.

P2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 22.22.22.22/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 22.22.22.22	Configure Router-id
(config-router)#transport-address ipv4 22.22.22.22	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface ge6.300	Enter interface mode
(config-if)#encapsulation dot1q 300	Configure encapsulation under a subinterface
(config-if)#ip address 15.0.0.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface ge6.1001	Enter interface mode
(config-if)#encapsulation dot1q 1001	Configure encapsulation under a subinterface
(config-if)#ip address 15.0.1.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po2000	Enter the Interface mode for po2000
(config-if)#exit	Exit interface mode
(config)#interface po2000.100	Enter interface mode for po2000.100
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#ip address 11.0.0.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface ge5	Enter interface mode
(config-if)#channel-group 2000 mode active	Moving interface to Dynamic LAG
(config)#interface ge11	Enter interface mode
(config-if)#channel-group 2000 mode active	Moving interface to Dynamic LAG
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 22.22.22.22	Configure ospf Router-id

(config-router)#network 15.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 15.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 11.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 22.22.22.22/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#exit	Exit from router mode
(config)#commit	Commit the transaction.

P3

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 33.33.33.33/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 33.33.33.33	Configure Router-id
(config-router)#transport-address ipv4 33.33.33.33	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface ge5	Enter interface mode
(config-if)#ip address 16.0.0.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface ge5.1001	Enter interface mode
(config-if)#encapsulation dot1q 1001	Configure encapsulation under a subinterface
(config-if)#ip address 16.0.1.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface sa4000	Enter the Interface mode for sa4000
(config-if)#exit	Exit interface mode
(config)#interface sa4000.200	Enter interface mode for psa4000.200

(config-if)#encapsulation dot1q 200	Configure encapsulation under a subinterface
(config-if)#ip address 17.0.0.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe12	Enter interface mode
(config-if)# static-channel-group 4000	Moving interface to Static LAG
(config)#interface xe13	Enter interface mode
(config-if)# static-channel-group 4000	Moving interface to Static LAG
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 33.33.33.33	Configure ospf Router-id
(config-router)#network 16.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 16.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 17.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 33.33.33.33/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#exit	Exit from router mode
(config)#commit	Commit the transaction.

P4

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 44.44.44.44/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 44.44.44.44	Configure Router-id
(config-router)#transport-address ipv4 44.44.44.44	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface sa3000	Enter the Interface mode for sa3000
(config-if)#exit	Exit interface mode

(config)#interface sa3000	Enter interface mode
(config-if)#ip address 18.0.0.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface sa3000.1001	Enter interface mode
(config-if)#encapsulation dot1q 1001	Configure encapsulation under a subinterface
(config-if)#ip address 18.0.1.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface sa4000	Enter the Interface mode for sa4000
(config-if)#exit	Exit interface mode
(config)#interface sa4000.200	Enter interface mode for psa4000.200
(config-if)#encapsulation dot1q 200	Configure encapsulation under a subinterface
(config-if)#ip address 17.0.0.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe6	Enter interface mode
config-if)#speed 1g	Configure speed 1g
(config-if)#static-channel-group 3000	Moving interface to Static LAG
(config)#interface xe8	Enter interface mode
config-if)#speed 1g	Configure speed 1g
(config-if)#static-channel-group 3000	Moving interface to Static LAG
(config)#interface xe12	Enter interface mode
(config-if)# static-channel-group 4000	Moving interface to Static LAG
(config)#interface xe13	Enter interface mode
(config-if)# static-channel-group 4000	Moving interface to Static LAG
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 44.44.44.44	Configure ospf Router-id

(config-router)#network 18.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 18.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 17.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 44.44.44.44/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#exit	Exit from router mode
(config)#commit	Commit the transaction.

PE2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 222.222.222.222/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 222.222.222.222	Configure Router-id
(config-router)#targeted-peer ipv4 111.111.111.111	Configuring targeted LDP sessions to PE-2
(config-router)#explicit-null	Configure explicit-null.
(config-router)#entropy-label-capability	Enable entropy capability in ldp
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)#transport-address ipv4 222.222.222.222	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface xe14	Enter interface mode
(config-if)#speed 1g	Configure interface speed to 1g
(config)#interface xe14.1001	Enter interface mode
(config-if)#encapsulation dot1q 1001	Configure encapsulation under a subinterface
(config-if)#ip address 15.0.1.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe14.1002	Enter interface mode
(config-if)#encapsulation dot1q 300	Configure encapsulation under a subinterface
(config-if)#ip address 15.0.0.20/24	Configure IP address on interface

(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface sa3000	Enter interface mode
(config-if)#ip address 18.0.0.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface sa3000.1001	Enter interface mode
(config-if)#encapsulation dot1q 1001	Configure encapsulation under a subinterface
(config-if)#ip address 18.0.1.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface ge5	Enter interface mode
(config-if)# static-channel-group 3000	Moving interface to static LAG
(config-if)#interface ge7	Enter interface mode
(config-if)# static-channel-group 3000	Moving interface to static LAG
(config-if)#exit	Exit interface mode
(config)#interface ge9	Enter interface mode
(config-if)#ip address 9.0.0.20/24	Configure IP address on interface
(config-if)#ip ospf cost 20	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#ip vrf l3vpnvrf300	IP VRF config with name l3vpnvrf300
(config-vrf)#rd 300:1	Route-distinguisher value
(config-vrf)#route-target both 300:1	Route target value
(config-vrf)#exit	Exit to config mode
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 222.222.222.222	Configure ospf Router-id

(config-router)#network 9.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 15.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 15.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 18.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 18.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 222.222.222.222/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#router bgp 100	Configure router bgp in AS 100
(config-router)#bgp router-id 222.222.222.222	Configure BGP router ID
(config-router)#neighbor 111.111.111.111 remote-as 100	Configure neighbor in remote-as 100
(config-router)#neighbor 111.111.111.111 update-source lo	Configure neighbor with update-source loopback
(config-router)#address-family vpnv4 unicast	Enter VPNv4 Address family mode
(config-router-af)#neighbor 111.111.111.111 activate	mode Activate VPNv4 neighbor
(config-router-af)#exit-address-family	Exit from Address Family configuration
(config-router)#address-family l2vpn vpls	Enter vpls Address family mode
(config-router-af)#neighbor 111.111.111.111 activate	mode Activate vpls neighbor
(config-router-af)#exit-address-family	Exit from Address Family configuration
(config-router)#address-family vrf l3vpnvrf300	Configure VRF address family
(config-router-af)#redistribute connected	Redistribute connected addresses
(config-router-af)#exit-address-family	Exit from Address Family configuration
(config-router)#exit	Exit from router mode
(config)#mpls vplsldp100 100	Configuring VPLS instance with name and VPLS ID
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance
(config-vpls-sig)# vpls-peer 111.111.111.111	Configuring VPLS mesh peers
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config)#mpls l2-circuit VPWS400 400 111.111.111.111	Configuring VPWS instance with name and VPWS ID
(config)#mpls vpls vplsbgp200 200	Configuring VPLS instance with name and VPLS ID
(config-vpls)#signaling bgp	Enabling LDP signaling for the VPLS instance

(config-vpls-sig)#ve-id 201	Configure VE ID, which is mandatory for BGP VPLS, otherwise, signaling does not take place. VE ID should be unique per VPLS instance
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config-if)#interface xe12.100 switchport	Enter sub interface mode
(config-if)#split-horizon group access1	Configure split-horizon group on sub-interface
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls vplsldp100	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#exit	Exit from access mode
(config-if)#interface xe12.400 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 400	Configure encapsulation under a subinterface
(config-if)#access-if-vpws	Access VPWS under sub interface
(config-acc-if-vpws)#mpls-vpws VPWS400	Associating the VPWS Instance to the attachment circuit interface.
(config-acc-if-vpws)#exit	Exit from access mode
(config-if)#interface xe12.200 switchport	Enter sub interface mode
(config-if)#split-horizon group access1	Configure split-horizon group on sub-interface
(config-if)#encapsulation dot1q 200	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls vplsbgp200	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#exit	Exit from access mode
(config-if)#interface xe12.300	Enter sub interface mode
(config-if)#encapsulation dot1q 300	Configure encapsulation under a subinterface
(config-if)#ip vrf forwarding l3vpnvrf300	Attaching xe12.300 to as part of l3vpnvrf300
(config-if)#ip address 210.210.210.1/24	Configure the IP address of the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the configuration
(config)#end	Return to privilege mode

Validation

PE1

```
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```

```
PE1#show ip ospf neighbor
```

```
Total number of full neighbors: 4
OSPF process 100 VRF(default):
```

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
11.11.11.11 0	1	Full/Backup	00:00:30	10.0.0.20	po1000.1000
11.11.11.11 0	1	Full/Backup	00:00:34	10.0.1.20	xe13
33.33.33.33 0	1	Full/Backup	00:00:34	16.0.0.20	xe4
33.33.33.33 0	1	Full/Backup	00:00:34	16.0.1.20	xe4.1001

PE1#

PE1#show ip ospf interface brief

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
lo	100	0.0.0.0	1	1	Loopback	0	Up
xe4	100	0.0.0.0	10005	10	DR	1	Up
xe13	100	0.0.0.0	10014	10	DR	1	Up
xe4.1001	100	0.0.0.0	327844841	10	DR	1	Up
po1000.1000	100	0.0.0.0	524289000	10	DR	1	Up

PE1#

PE1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
11.11.11.11	xe13	Active	OPERATIONAL	30	00:00:33
33.33.33.33	xe4.1001	Active	OPERATIONAL	30	00:00:33
222.222.222.222	xe4.1001	Passive	OPERATIONAL	30	00:00:22

PE1#

PE1#show bgp neighbors

BGP neighbor is 222.222.222.222, remote AS 100, local AS 100, internal link
 BGP version 4, local router ID 111.111.111.111, remote router ID 222.222.222.222
 BGP state = Established, up for 00:00:27
 Last read 00:00:08, hold time is 90, keepalive interval is 30 seconds
 Neighbor capabilities:
 Route refresh: advertised and received (old and new)
 Address family IPv4 Unicast: advertised and received
 Address family VPNv4 Unicast: advertised and received
 Address family L2VPN VPLS: advertised and received
 Address family L2VPN EVPN: advertised and received
 Address family IPv6 Unicast: advertised and received
 Address family VPNv6 Unicast: advertised and received

Address family IPv6 Labeled Unicast: advertised and received
Received 11 messages, 0 notifications, 0 in queue
Sent 13 messages, 0 notifications, 0 in queue
Route refresh request: received 0, sent 0
Minimum time between advertisement runs is 5 seconds
Update source is lo

For address family: VPNv4 Unicast
BGP table version 2, neighbor version 2
Index 1, Offset 0, Mask 0x2
AIGP is enabled
Community attribute sent to this neighbor (both)
Large Community attribute sent to this neighbor
1 accepted prefixes
1 announced prefixes

For address family: L2VPN VPLS
BGP table version 1, neighbor version 1
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (both)
Large Community attribute sent to this neighbor
0 accepted prefixes
1 announced prefixes

Connections established 1; dropped 0
Local host: 111.111.111.111, Local port: 179
Foreign host: 222.222.222.222, Foreign port: 35033
Nexthop: 111.111.111.111
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

PE1#

PE1#show mpls vpls

Name	VPLS-ID	Type	MPeers	SPeers	SIG-
Protocol Learning					
vplsldp100	100	Ethernet	1	0	LDP
Enabled					
vplsbgp200	200	Ethernet	1	0	BGP
Enabled					

PE1#

PE1#show mpls vpls mesh

(m) - Service mapped over multipath transport

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St
PW-INDEX	SIG-Protocol	Status				

```

100      222.222.222.222  25611      26253      xe13      26246      2/Up
1        LDP              Active
200      222.222.222.222  25611      25608      xe13      25607      2/Up
3        BGP              Active
PE1#

```

```

PE1#show mpls vc-table
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

```

VC-ID	Vlan-ID	Inner-Vlan-ID	Access-Intf	Network-Intf	Out Label	Tunnel-Label
Nexthop	Status					
400						

```

PE1#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: VPWS400, id: 400 PW-INDEX: 2 service-tpid: dot1.q
Endpoint: 222.222.222.222
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe8.400
Subinterface Match Criteria(s) :
  dot1q 400
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active

```

```
PE1#
```

```

PE1#show mpls vrf-forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, B - BGP FTN
(m) - Service mapped over multipath transport

```

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-
Intf	Nexthop						
B>	210.210.210.0/24	1	-	-	LSP_DEFAULT	25664	-
	222.222.222.222						
B>	210::/64	2	-	-	LSP_DEFAULT	25664	-
	222.222.222.222						

```
PE1#
```

```

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
      B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
      L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
      U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport, (e) - FTN is ECMP

```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	9.0.0.0/24	1	73 (e)				
xe13	No	10.0.1.20	52	-	Yes	LSP_DEFAULT	3
xe4	No	222.222.222.222	71	-	No	LSP_DEFAULT	0
(via 16.0.0.20 ,label 25612)							
po1000.1000	No	10.0.0.20	53	-	Yes	LSP_DEFAULT	3
xe4	No	222.222.222.222	71	-	No	LSP_DEFAULT	0
(via 16.0.0.20 ,label 25612)							
L>	11.0.0.0/24	2	73 (e)				
xe13	No	10.0.1.20	52	-	Yes	LSP_DEFAULT	3
xe4	No	222.222.222.222	71	-	No	LSP_DEFAULT	0
(via 16.0.0.20 ,label 25612)							
po1000.1000	No	10.0.0.20	53	-	Yes	LSP_DEFAULT	3
xe4	No	222.222.222.222	71	-	No	LSP_DEFAULT	0
(via 16.0.0.20 ,label 25612)							
L>	11.11.11.11/32	3	100 (e)				
xe13	No	10.0.1.20	52	-	Yes	LSP_DEFAULT	3
po1000.1000	No	10.0.0.20	53	-	No	LSP_DEFAULT	3
po1000.1000	No	10.0.0.20	53	-	Yes	LSP_DEFAULT	3
xe13	No	10.0.1.20	52	-	No	LSP_DEFAULT	3
L>	15.0.0.0/24	4	77 (e)				
xe13	No	10.0.1.20	56	-	Yes	LSP_DEFAULT	25600
xe4	No	222.222.222.222	71	-	No	LSP_DEFAULT	0
(via 16.0.0.20 ,label 25612)							
po1000.1000	No	10.0.0.20	57	-	Yes	LSP_DEFAULT	25600
xe4	No	222.222.222.222	71	-	No	LSP_DEFAULT	0
(via 16.0.0.20 ,label 25612)							
L>	15.0.1.0/24	5	80 (e)				
xe13	No	10.0.1.20	60	-	Yes	LSP_DEFAULT	25601
xe4	No	222.222.222.222	71	-	No	LSP_DEFAULT	0

								(via
16.0.0.20 ,label 25612)								
po1000.1000	No	10.0.0.20	61	-	Yes	LSP_DEFAULT	25601	
xe4	No	222.222.222.222	71	-	No	LSP_DEFAULT	0	
								(via
16.0.0.20 ,label 25612)								
L>		17.0.0.0/24	6	84 (e)				
xe4	No	16.0.0.20	16	-	Yes	LSP_DEFAULT	3	
po1000.1000	No	222.222.222.222	82	-	No	LSP_DEFAULT	26249	
								(via
10.0.0.20 ,label 25611)								
xe4.1001	No	16.0.1.20	17	-	Yes	LSP_DEFAULT	3	
po1000.1000	No	222.222.222.222	82	-	No	LSP_DEFAULT	26249	
								(via
10.0.0.20 ,label 25611)								
L>		18.0.0.0/24	7	88 (e)				
xe4	No	16.0.0.20	19	-	Yes	LSP_DEFAULT	25608	
po1000.1000	No	222.222.222.222	86	-	No	LSP_DEFAULT	0	
								(via
10.0.0.20 ,label 25611)								
xe4.1001	No	16.0.1.20	20	-	Yes	LSP_DEFAULT	25608	
po1000.1000	No	222.222.222.222	86	-	No	LSP_DEFAULT	0	
								(via
10.0.0.20 ,label 25611)								
L>		18.0.1.0/24	8	91 (e)				
xe4	No	16.0.0.20	22	-	Yes	LSP_DEFAULT	25609	
po1000.1000	No	222.222.222.222	86	-	No	LSP_DEFAULT	0	
								(via
10.0.0.20 ,label 25611)								
xe4.1001	No	16.0.1.20	23	-	Yes	LSP_DEFAULT	25609	
po1000.1000	No	222.222.222.222	86	-	No	LSP_DEFAULT	0	
								(via
10.0.0.20 ,label 25611)								
L>		22.22.22.22/32	9	94 (e)				
xe13	No	10.0.1.20	64	-	Yes	LSP_DEFAULT	25607	
xe4	No	222.222.222.222	71	-	No	LSP_DEFAULT	0	
								(via
16.0.0.20 ,label 25612)								
po1000.1000	No	10.0.0.20	65	-	Yes	LSP_DEFAULT	25607	

```

xe4          No      222.222.222.222      71      -      No      LSP_DEFAULT  0
                                                    (via
16.0.0.20 ,label 25612)
  L>   33.33.33.33/32      10      102 (e)
xe4          No      16.0.0.20      16      -      Yes      LSP_DEFAULT  3
xe4.1001     No      16.0.1.20      17      -      No      LSP_DEFAULT  3
xe4.1001     No      16.0.1.20      17      -      Yes      LSP_DEFAULT  3
xe4          No      16.0.0.20      16      -      No      LSP_DEFAULT  3
  L>   44.44.44.44/32      11      98 (e)
xe4          No      16.0.0.20      28      -      Yes      LSP_DEFAULT  25611
po1000.1000 No      222.222.222.222      96      -      No      LSP_DEFAULT  26251
                                                    (via
10.0.0.20 ,label 25611)
xe4.1001     No      16.0.1.20      29      -      Yes      LSP_DEFAULT  25611
po1000.1000 No      222.222.222.222      96      -      No      LSP_DEFAULT  26251
                                                    (via
10.0.0.20 ,label 25611)
  L>   222.222.222.222/32  12      104 (e)
xe13         Yes     10.0.1.20      68      -      Yes      LSP_DEFAULT  25611
xe4          Yes     16.0.0.20      31      -      No      LSP_DEFAULT  25612
po1000.1000 Yes     10.0.0.20      69      -      Yes      LSP_DEFAULT  25611
xe4          Yes     16.0.0.20      31      -      No      LSP_DEFAULT  25612
xe4          Yes     16.0.0.20      31      -      Yes      LSP_DEFAULT  25612
po1000.1000 Yes     10.0.0.20      69      -      No      LSP_DEFAULT  25611
xe4.1001     Yes     16.0.1.20      32      -      Yes      LSP_DEFAULT  25612
po1000.1000 Yes     10.0.0.20      69      -      No      LSP_DEFAULT  25611
  B>   220::/64      13      49      -      -      LSP_DEFAULT  25665
-      No      222.222.222.222
PE1#

```

PE1#show interface counters rate mbps

Interface	Rx mbps	Rx pps	Tx mbps	Tx pps
po1000	350.55	4850	250.40	3466
po1000.1000	350.55	4851	250.39	3465
xe0	0.00	0	0.00	0

xe2	0.00	0	0.00	0
xe4	400.63	5546	500.68	6932
xe4.1001	400.63	5545	250.40	3465
xe8	997.81	13858	997.81	13858
xe8.400	997.80	13858	997.80	13858
xe12	350.56	4850	250.40	3466
xe13	250.28	3467	250.29	3466

PE1#

P1

P1#show ip ospf interface brief

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
lo	100	0.0.0.0	1	1	Loopback	0	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
ge8	100	0.0.0.0	10009	20	Backup	1	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
ge13	100	0.0.0.0	10014	10	Backup	1	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
po1000.1000	100	0.0.0.0	524289000	10	Backup	1	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
po2000.100	100	0.0.0.0	557056100	10	Backup	1	Up

P1#

P1#show ip ospf neighbor

Total number of full neighbors: 4

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface
Instance ID					
222.222.222.222	1	Full/DR	00:00:38	9.0.0.20	ge8
0					
111.111.111.111	1	Full/DR	00:00:36	10.0.0.10	po1000.1000
0					
111.111.111.111	1	Full/DR	00:00:34	10.0.1.10	ge13
0					
22.22.22.22	1	Full/DR	00:00:38	11.0.0.20	po2000.100
0					

P1#

P1#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
22.22.22.22	po2000.100	Passive	OPERATIONAL	30	00:01:27


```

222.222.222.222      ge8      Passive  OPERATIONAL  30    00:00:19
111.111.111.111      ge13     Passive  OPERATIONAL  30    00:00:32
33.33.33.33          ge13     Passive  OPERATIONAL  30    00:00:21
44.44.44.44          po2000.100 Passive  OPERATIONAL  30    00:00:14
Pl#

```

Pl#show interface counters rate mbps

Interface	Rx mbps	Rx pps	Tx mbps	Tx pps
ge8	190.14	2634	250.19	3464
ge10	0.00	0	0.00	0
ge12	250.30	3465	350.42	4848
ge13	250.19	3465	250.19	3465
po1000	250.30	3465	350.42	4849
po1000.1000	250.31	3465	350.42	4848
po2000	410.50	5680	250.30	3464
po2000.100	410.50	5681	250.30	3464
xe23	220.26	3048	120.15	1663
xe24	190.23	2632	130.16	1801
xe26	0.00	0	0.00	0

Pl#

Pl#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM
 K - CLI ILM, T - MPLS-TP, s - Stitched ILM
 S - SNMP, L - LDP, R - RSVP, C - CRLDP
 B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
 O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
 P - SR Policy, U - unknown

LDP ilm-ecmp - enabled

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf/VRF
NextHop		pri	LSP-Type			
L> 111.111.111.111/32	22	25621	0	N/A	ge13	
10.0.1.10	Yes	LSP_DEFAULT	0	N/A	po1000.1000	
10.0.0.10	No	LSP_DEFAULT	0	N/A	po1000.1000	
10.0.0.10	Yes	LSP_DEFAULT	0	N/A	ge13	
10.0.1.10	No	LSP_DEFAULT	0	N/A	ge13	
L> 16.0.1.0/24	9	25608	0	N/A	ge13	
10.0.1.10	Yes	LSP_DEFAULT	0	N/A	po1000.1000	
10.0.0.10	Yes	LSP_DEFAULT	0	N/A	po1000.1000	
L> 15.0.0.0/24	3	25602	3	N/A	po2000.100	
11.0.0.20	Yes	LSP_DEFAULT	0	N/A	ge8	
9.0.0.20	No	LSP_DEFAULT	0	N/A	ge8	
L> 15.0.1.0/24	2	25601	3	N/A	po2000.100	
11.0.0.20	Yes	LSP_DEFAULT	0	N/A	po2000.100	

9.0.0.20	No	25601 LSP_DEFAULT	0	N/A	ge8
L> 15.0.0.0/24	1	25600	3	N/A	po2000.100
11.0.0.20	Yes	LSP_DEFAULT			
9.0.0.20	No	25600 LSP_DEFAULT	0	N/A	ge8
L> 16.0.0.0/24	5	25604	0	N/A	ge13
10.0.1.10	Yes	LSP_DEFAULT			
10.0.0.10	Yes	25604 LSP_DEFAULT	0	N/A	po1000.1000
L> 15.0.1.0/24	4	25603	3	N/A	po2000.100
11.0.0.20	Yes	LSP_DEFAULT			
9.0.0.20	No	25603 LSP_DEFAULT	0	N/A	ge8
L> 18.0.1.0/24	7	25606	25604	N/A	po2000.100
11.0.0.20	Yes	LSP_DEFAULT			
9.0.0.20	Yes	25606 LSP_DEFAULT	0	N/A	ge8
44.44.44.44	No	25606 LSP_DEFAULT	3	N/A	ge8
9.0.0.20 ,label 26269)					(via
L> 18.0.0.0/24	6	25605	25603	N/A	po2000.100
11.0.0.20	Yes	LSP_DEFAULT			
9.0.0.20	Yes	25605 LSP_DEFAULT	0	N/A	ge8
44.44.44.44	No	25605 LSP_DEFAULT	3	N/A	ge8
9.0.0.20 ,label 26269)					(via
L> 22.22.22.22/32	8	25607	3	N/A	po2000.100
11.0.0.20	Yes	LSP_DEFAULT			
9.0.0.20	No	25607 LSP_DEFAULT	26267	N/A	ge8
L> 111.111.111.111/32	17	25616	0	N/A	ge13
10.0.1.10	Yes	LSP_DEFAULT			
10.0.0.10	No	25616 LSP_DEFAULT	0	N/A	po1000.1000
10.0.0.10	Yes	25616 LSP_DEFAULT	0	N/A	po1000.1000
10.0.1.10	No	25616 LSP_DEFAULT	0	N/A	ge13
L> 16.0.1.0/24	14	25613	0	N/A	ge13
10.0.1.10	Yes	LSP_DEFAULT			
10.0.0.10	Yes	25613 LSP_DEFAULT	0	N/A	po1000.1000
L> 18.0.0.0/24	11	25610	25603	N/A	po2000.100
11.0.0.20	Yes	LSP_DEFAULT			
9.0.0.20	Yes	25610 LSP_DEFAULT	0	N/A	ge8
L> 17.0.0.0/24	10	25609	26245	N/A	ge13
10.0.1.10	Yes	LSP_DEFAULT			
10.0.0.10	Yes	25609 LSP_DEFAULT	26245	N/A	po1000.1000
L> 16.0.0.0/24	13	25612	0	N/A	ge13
10.0.1.10	Yes	LSP_DEFAULT			

10.0.0.10	Yes	25612 LSP_DEFAULT	0	N/A	po1000.1000	
L> 222.222.222.222/32	12	25611	25607	N/A	po2000.100	
11.0.0.20	Yes	LSP_DEFAULT				
9.0.0.20	Yes	25611 LSP_DEFAULT	0	N/A	ge8	
44.44.44.44	No	25611 LSP_DEFAULT	25624	N/A	ge8	
9.0.0.20 ,label 26269)						(via
L> 17.0.0.0/24	15	25614	26245	N/A	ge13	
10.0.1.10	Yes	LSP_DEFAULT				
44.44.44.44	No	25614 LSP_DEFAULT	3	N/A	ge8	
9.0.0.20 ,label 26269)						(via
10.0.0.10	Yes	25614 LSP_DEFAULT	26245	N/A	po1000.1000	
44.44.44.44	No	25614 LSP_DEFAULT	3	N/A	ge8	
9.0.0.20 ,label 26269)						(via
L> 33.33.33.33/32	16	25615	26249	N/A	ge13	
10.0.1.10	Yes	LSP_DEFAULT				
44.44.44.44	No	25615 LSP_DEFAULT	25622	N/A	ge8	
9.0.0.20 ,label 26269)						(via
10.0.0.10	Yes	25615 LSP_DEFAULT	26249	N/A	po1000.1000	
44.44.44.44	No	25615 LSP_DEFAULT	25622	N/A	ge8	
9.0.0.20 ,label 26269)						(via
L> 22.22.22.22/32	19	25618	3	N/A	po2000.100	
11.0.0.20	Yes	LSP_DEFAULT				
9.0.0.20	No	25618 LSP_DEFAULT	26267	N/A	ge8	
L> 18.0.1.0/24	18	25617	25604	N/A	po2000.100	
11.0.0.20	Yes	LSP_DEFAULT				
9.0.0.20	Yes	25617 LSP_DEFAULT	0	N/A	ge8	
L> 33.33.33.33/32	20	25619	26249	N/A	ge13	
10.0.1.10	Yes	LSP_DEFAULT				
10.0.0.10	Yes	25619 LSP_DEFAULT	26249	N/A	po1000.1000	
L> 44.44.44.44/32	21	25620	25606	N/A	po2000.100	
11.0.0.20	Yes	LSP_DEFAULT				
9.0.0.20	No	25620 LSP_DEFAULT	26269	N/A	ge8	
10.0.1.10	Yes	25620 LSP_DEFAULT	26250	N/A	ge13	
9.0.0.20	No	25620 LSP_DEFAULT	26269	N/A	ge8	
10.0.0.10	Yes	25620 LSP_DEFAULT	26250	N/A	po1000.1000	

9.0.0.20	No	25620 LSP_DEFAULT	26269	N/A	ge8
9.0.0.20	Yes	25620 LSP_DEFAULT	26269	N/A	ge8
10.0.0.10	No	25620 LSP_DEFAULT	26250	N/A	po1000.1000
L> 33.33.33.33/32	32	25631	26249	N/A	ge13
10.0.1.10	Yes	LSP_DEFAULT	25631	N/A	po1000.1000
10.0.0.10	Yes	LSP_DEFAULT	25625	0	N/A
L> 16.0.0.0/24	26	LSP_DEFAULT	25625	0	N/A
10.0.1.10	Yes	LSP_DEFAULT	25625	0	N/A
10.0.0.10	Yes	LSP_DEFAULT	25623	3	N/A
L> 15.0.0.0/24	24	LSP_DEFAULT	25623	3	N/A
11.0.0.20	Yes	LSP_DEFAULT	25623	0	N/A
9.0.0.20	No	LSP_DEFAULT	25622	25607	N/A
L> 222.222.222.222/32	23	LSP_DEFAULT	25622	0	N/A
11.0.0.20	Yes	LSP_DEFAULT	25624	3	N/A
9.0.0.20	Yes	LSP_DEFAULT	25624	0	N/A
L> 15.0.1.0/24	25	LSP_DEFAULT	25624	0	N/A
11.0.0.20	Yes	LSP_DEFAULT	25627	26245	N/A
9.0.0.20	No	LSP_DEFAULT	25627	26245	N/A
L> 17.0.0.0/24	28	LSP_DEFAULT	25626	0	N/A
10.0.1.10	Yes	LSP_DEFAULT	25626	0	N/A
10.0.0.10	Yes	LSP_DEFAULT	25629	25604	N/A
L> 16.0.1.0/24	27	LSP_DEFAULT	25629	0	N/A
10.0.1.10	Yes	LSP_DEFAULT	25628	25603	N/A
10.0.0.10	Yes	LSP_DEFAULT	25628	0	N/A
L> 18.0.1.0/24	30	LSP_DEFAULT	25630	3	N/A
11.0.0.20	Yes	LSP_DEFAULT	25630	26267	N/A
9.0.0.20	No	LSP_DEFAULT	25637	0	N/A
L> 16.0.0.0/24	38	LSP_DEFAULT	25637	0	N/A
10.0.1.10	Yes	LSP_DEFAULT	25635	3	N/A
10.0.0.10	Yes	LSP_DEFAULT	25633	0	N/A
L> 15.0.0.0/24	36	LSP_DEFAULT	25633	0	N/A
11.0.0.20	Yes	LSP_DEFAULT	25633	0	N/A
L> 111.111.111.111/32	34	LSP_DEFAULT	25633	0	N/A
10.0.1.10	Yes	LSP_DEFAULT	25633	0	N/A
10.0.0.10	No	LSP_DEFAULT	25633	0	N/A

10.0.0.10	Yes	25633 LSP_DEFAULT	0	N/A	po1000.1000
10.0.1.10	No	25633 LSP_DEFAULT	0	N/A	ge13
L> 44.44.44.44/32	33	25632	25606	N/A	po2000.100
11.0.0.20	Yes	LSP_DEFAULT	26269	N/A	ge8
9.0.0.20	No	LSP_DEFAULT	26250	N/A	ge13
10.0.1.10	Yes	LSP_DEFAULT	26269	N/A	ge8
9.0.0.20	No	LSP_DEFAULT	26250	N/A	po1000.1000
10.0.0.10	Yes	LSP_DEFAULT	26269	N/A	ge8
9.0.0.20	No	LSP_DEFAULT	26269	N/A	ge8
10.0.0.10	No	LSP_DEFAULT	26250	N/A	po1000.1000
L> 222.222.222.222/32	35	25634	25607	N/A	po2000.100
11.0.0.20	Yes	LSP_DEFAULT	0	N/A	ge8
9.0.0.20	Yes	LSP_DEFAULT	3	N/A	po2000.100
L> 15.0.1.0/24	37	25640	3	N/A	po2000.100
11.0.0.20	Yes	LSP_DEFAULT	0	N/A	ge13
L> 22.22.22.22/32	41	25638	0	N/A	po1000.1000
11.0.0.20	Yes	LSP_DEFAULT	26245	N/A	ge13
L> 16.0.1.0/24	39	25639	3	N/A	ge8
10.0.1.10	Yes	LSP_DEFAULT	26245	N/A	po1000.1000
10.0.0.10	Yes	LSP_DEFAULT	26245	N/A	ge13
L> 17.0.0.0/24	40	25639	3	N/A	ge8
10.0.1.10	Yes	LSP_DEFAULT	3	N/A	ge8
44.44.44.44	No	LSP_DEFAULT			(via
9.0.0.20 ,label 26269)					
10.0.0.10	Yes	25639 LSP_DEFAULT	26245	N/A	po1000.1000
44.44.44.44	No	25639 LSP_DEFAULT	3	N/A	ge8
9.0.0.20 ,label 26269)					(via
L> 111.111.111.111/32	43	25642	0	N/A	ge13
10.0.1.10	Yes	LSP_DEFAULT	0	N/A	po1000.1000
10.0.0.10	No	LSP_DEFAULT	0	N/A	po1000.1000
10.0.0.10	Yes	LSP_DEFAULT	0	N/A	ge13
10.0.1.10	No	LSP_DEFAULT	26249	N/A	ge13
L> 33.33.33.33/32	42	25641	25622	N/A	ge8
10.0.1.10	Yes	LSP_DEFAULT			
44.44.44.44	No	LSP_DEFAULT			

```
9.0.0.20 ,label 26269)
                                25641      26249      N/A      po1000.1000
10.0.0.10                      Yes      LSP_DEFAULT
                                25641      25622      N/A      ge8
44.44.44.44                    No      LSP_DEFAULT
                                (via
9.0.0.20 ,label 26269)
P1#
```

P2

P2#show ip ospf interface brief

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
lo	100	0.0.0.0	1	1	Loopback	0	Up

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
ge6.300	100	0.0.0.0	328171820	10	Backup	1	Up

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
ge6.1001	100	0.0.0.0	328172521	10	Backup	1	Up

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
po2000.100	100	0.0.0.0	557056100	10	DR	1	Up

P2#

P2#show ip ospf neighbor

Total number of full neighbors: 3

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
11.11.11.11 0	1	Full/Backup	00:00:32	11.0.0.10	po2000.100
222.222.222.222 0	1	Full/DR	00:00:36	15.0.0.20	ge6.300
222.222.222.222 0	1	Full/DR	00:00:35	15.0.1.20	ge6.1001

P2#

P2#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
222.222.222.222	ge6.1001	Passive	OPERATIONAL	30	00:00:21
11.11.11.11	po2000.100	Active	OPERATIONAL	30	00:01:27
33.33.33.33	po2000.100	Passive	OPERATIONAL	30	00:00:14

P2#

P3

P3#show ip ospf interface brief

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
-----------	-----	------	---------	------	-------	-----------	--------

lo	100	0.0.0.0	1	1	Loopback	0	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
ge5	100	0.0.0.0	10014	10	Backup	1	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
ge5.1001	100	0.0.0.0	328139753	10	Backup	1	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
sa4000.200	100	0.0.0.0	1179648200	10	Backup	1	Up

P3#

P3#show ip ospf neighbor

Total number of full neighbors: 3

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
111.111.111.111 0	1	Full/DR	00:00:38	16.0.0.10	ge5
111.111.111.111 0	1	Full/DR	00:00:32	16.0.1.10	ge5.1001
44.44.44.44 0	1	Full/DR	00:00:36	17.0.0.10	sa4000.200

P3#

P3#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
44.44.44.44	sa4000.200	Passive	OPERATIONAL	30	00:02:00
111.111.111.111	ge5	Passive	OPERATIONAL	30	00:00:32
22.22.22.22	ge5	Active	OPERATIONAL	30	00:00:14
11.11.11.11	ge5	Active	OPERATIONAL	30	00:00:20
222.222.222.222	sa4000.200	Passive	OPERATIONAL	30	00:00:13

P3#

P4

P4#show ip ospf interface brief

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
lo	100	0.0.0.0	1	1	Loopback	0	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
sa3000	100	0.0.0.0	203000	10	Backup	1	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
sa3000.1001	100	0.0.0.0	1146881001	10	Backup	1	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
sa4000.200	100	0.0.0.0	1179648200	10	DR	1	Up

P4#

P4#show ip ospf neighbor

Total number of full neighbors: 3

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
33.33.33.33 0	1	Full/Backup	00:00:34	17.0.0.20	sa4000.200
222.222.222.222 0	1	Full/DR	00:00:36	18.0.0.20	sa3000
222.222.222.222 0	1	Full/DR	00:00:34	18.0.1.20	sa3000.1001

P4#

P4#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
222.222.222.222	sa3000	Passive	OPERATIONAL	30	00:00:40
33.33.33.33	sa4000.200	Active	OPERATIONAL	30	00:02:00
11.11.11.11	sa4000.200	Active	OPERATIONAL	30	00:00:14

P4#

PE2

PE2#show ip ospf neighbor

Total number of full neighbors: 5

OSPF process 100 VRF(default):

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
11.11.11.11 0	1	Full/Backup	00:00:36	9.0.0.10	ge9
22.22.22.22 0	1	Full/Backup	00:00:31	15.0.0.10	xe14.1002
22.22.22.22 0	1	Full/Backup	00:00:34	15.0.1.10	xe14.1001
44.44.44.44 0	1	Full/Backup	00:00:38	18.0.0.10	sa3000
44.44.44.44 0	1	Full/Backup	00:00:31	18.0.1.10	sa3000.1001

PE2#

PE2#show ip ospf interface brief

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
lo	100	0.0.0.0	1	1	Loopback	0	Up

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
ge9	100	0.0.0.0	10018	20	DR	1	Up

Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
-----------	-----	------	---------	------	-------	-----------	--------

sa3000	100	0.0.0.0	203000	10	DR	1	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
xe14.1001	100	0.0.0.0	328434665	10	DR	1	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
xe14.1002	100	0.0.0.0	328434666	10	DR	1	Up
Interface	PID	Area	Intf ID	Cost	State	Neighbors	Status
sa3000.1001	100	0.0.0.0	1146881001	10	DR	1	Up

PE2#

PE2#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
44.44.44.44	sa3000	Active	OPERATIONAL	30	00:00:41
11.11.11.11	ge9	Active	OPERATIONAL	30	00:00:18
22.22.22.22	xe14.1002	Active	OPERATIONAL	30	00:00:25
111.111.111.111	xe14.1001	Active	OPERATIONAL	30	00:00:22
33.33.33.33	sa3000	Active	OPERATIONAL	30	00:00:14

PE2#

PE2#show bgp neighbors

BGP neighbor is 111.111.111.111, remote AS 100, local AS 100, internal link
 BGP version 4, local router ID 222.222.222.222, remote router ID 111.111.111.111
 BGP state = Established, up for 00:00:27
 Last read 00:00:01, hold time is 90, keepalive interval is 30 seconds
 Neighbor capabilities:
 Route refresh: advertised and received (old and new)
 Address family IPv4 Unicast: advertised and received
 Address family VPNv4 Unicast: advertised and received
 Address family L2VPN VPLS: advertised and received
 Address family L2VPN EVPN: advertised and received
 Address family IPv6 Unicast: advertised and received
 Address family VPNv6 Unicast: advertised and received
 Address family IPv6 Labeled Unicast: advertised and received
 Received 12 messages, 0 notifications, 0 in queue
 Sent 11 messages, 0 notifications, 0 in queue
 Route refresh request: received 0, sent 0
 Minimum time between advertisement runs is 5 seconds
 Update source is lo

For address family: VPNv4 Unicast

BGP table version 2, neighbor version 2

Index 1, Offset 0, Mask 0x2

AIGP is enabled

Community attribute sent to this neighbor (both)

Large Community attribute sent to this neighbor

```

1 accepted prefixes
1 announced prefixes

```

```

For address family: L2VPN VPLS
BGP table version 1, neighbor version 1
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (both)
Large Community attribute sent to this neighbor
0 accepted prefixes
1 announced prefixes

```

```

Connections established 1; dropped 0
Local host: 222.222.222.222, Local port: 35033
Foreign host: 111.111.111.111, Foreign port: 179
Nexthop: 222.222.222.222
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

```

```
PE2#
```

```
PE2#show mpls vpls
```

Name	VPLS-ID	Type	MPeers	SPeers	SIG-
Protocol Learning					
vplsldp100	100	Ethernet	1	0	LDP
Enabled					
vplsbgp200	200	Ethernet	1	0	BGP
Enabled					

```
PE2#
```

```
PE2#show mpls vpls mesh
```

```
(m) - Service mapped over multipath transport
```

VPLS-ID	Peer Addr	Tunnel-Label	In-Label	Network-Intf	Out-Label	Lkps/St
PW-INDEX	SIG-Protocol	Status				
100	111.111.111.111	25614	26246	sa3000.1001	26253	2/Up
1	LDP	Active				
200	111.111.111.111	25614	25607	sa3000.1001	25608	2/Up
3	BGP	Active				

```
PE2#
```

```
PE2#show mpls vc-table
```

```
(m) - Service mapped over multipath transport
```

```
(e) - Service mapped over LDP ECMP
```

VC-ID	Vlan-ID	Inner-Vlan-ID	Access-Intf	Network-Intf	Out Label	Tunnel-Label
Nexthop	Status					
400	N/A	N/A	xe12.400	N/A (e)	26252	N/A (e)
111.111.111.111	Active					

```
PE2#
```

```

PE2#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: VPWS400, id: 400  PW-INDEX: 2 service-tpid: dot1.q
Endpoint: 111.111.111.111
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12.400
Subinterface Match Criteria(s) :
  dot1q 400
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active

```

PE2#

```

PE2#show mpls vrf-forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, B - BGP FTN
(m) - Service mapped over multipath transport

```

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-
Intf	NextHop						
B>	110.110.110.0/24	2	-	-	LSP_DEFAULT	25664	-
	111.111.111.111						
B>	110::/64	1	-	-	LSP_DEFAULT	25664	-
	111.111.111.111						

PE2#

```

PE2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
      B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
      L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
      U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport, (e) - FTN is ECMP

```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	NextHop					
L>	10.0.0.0/24	8	56(e)				
xe14.1001	No	15.0.1.10	54	-	Yes	LSP_DEFAULT	25617
ge9	No	9.0.0.10	33	-	No	LSP_DEFAULT	3
xe14.1002	No	15.0.0.10	55	-	Yes	LSP_DEFAULT	25617
ge9	No	9.0.0.10	33	-	No	LSP_DEFAULT	3
ge9	No	9.0.0.10	33	-	Yes	LSP_DEFAULT	3
ge9	No	111.111.111.111	38	-	No	LSP_DEFAULT	0

9.0.0.10 ,label 25642)								(via
L>	10.0.1.0/24	9	59 (e)					
xe14.1001	No	15.0.1.10	57	-	Yes	LSP_DEFAULT	25618	
ge9	No	9.0.0.10	33	-	No	LSP_DEFAULT	3	
xe14.1002	No	15.0.0.10	58	-	Yes	LSP_DEFAULT	25618	
ge9	No	9.0.0.10	33	-	No	LSP_DEFAULT	3	
ge9	No	9.0.0.10	33	-	Yes	LSP_DEFAULT	3	
ge9	No	111.111.111.111	38	-	No	LSP_DEFAULT	0	
9.0.0.10 ,label 25642)								(via
L>	11.0.0.0/24	11	63 (e)					
xe14.1001	No	15.0.1.10	60	-	Yes	LSP_DEFAULT	3	
xe14.1002	No	15.0.0.10	61	-	Yes	LSP_DEFAULT	3	
ge9	No	111.111.111.111	62	-	No	LSP_DEFAULT	26255	
9.0.0.10 ,label 25642)								(via
L>	11.11.11.11/32	10	68 (e)					
xe14.1001	No	15.0.1.10	66	-	Yes	LSP_DEFAULT	25619	
ge9	No	9.0.0.10	33	-	No	LSP_DEFAULT	3	
xe14.1002	No	15.0.0.10	67	-	Yes	LSP_DEFAULT	25619	
ge9	No	9.0.0.10	33	-	No	LSP_DEFAULT	3	
ge9	No	9.0.0.10	33	-	Yes	LSP_DEFAULT	3	
ge9	No	111.111.111.111	40	-	No	LSP_DEFAULT	26256	
9.0.0.10 ,label 25642)								(via
L>	16.0.0.0/24	1	42 (e)					
sa3000.1001	No	18.0.1.10	1	-	Yes	LSP_DEFAULT	25604	
ge9	No	111.111.111.111	38	-	No	LSP_DEFAULT	0	
9.0.0.10 ,label 25642)								(via
sa3000	No	18.0.0.10	2	-	Yes	LSP_DEFAULT	25604	
ge9	No	111.111.111.111	38	-	No	LSP_DEFAULT	0	
9.0.0.10 ,label 25642)								(via
L>	16.0.1.0/24	2	43 (e)					

sa3000.1001	No	18.0.1.10	4	-	Yes	LSP_DEFAULT	25605	
ge9	No	111.111.111.111	38	-	No	LSP_DEFAULT	0	
9.0.0.10	,label	25642)						(via
sa3000	No	18.0.0.10	5	-	Yes	LSP_DEFAULT	25605	
ge9	No	111.111.111.111	38	-	No	LSP_DEFAULT	0	
9.0.0.10	,label	25642)						(via
L>	17.0.0.0/24	3	53 (e)					
sa3000.1001	No	18.0.1.10	7	-	Yes	LSP_DEFAULT	3	
ge9	No	33.33.33.33	52	-	No	LSP_DEFAULT	3	
9.0.0.10	,label	25641)						(via
sa3000	No	18.0.0.10	8	-	Yes	LSP_DEFAULT	3	
ge9	No	33.33.33.33	52	-	No	LSP_DEFAULT	3	
9.0.0.10	,label	25641)						(via
L>	22.22.22.22/32	12	69 (e)					
xe14.1001	No	15.0.1.10	60	-	Yes	LSP_DEFAULT	3	
xe14.1002	No	15.0.0.10	61	-	No	LSP_DEFAULT	3	
xe14.1002	No	15.0.0.10	61	-	Yes	LSP_DEFAULT	3	
xe14.1001	No	15.0.1.10	60	-	No	LSP_DEFAULT	3	
L>	33.33.33.33/32	4	45 (e)					
sa3000.1001	No	18.0.1.10	10	-	Yes	LSP_DEFAULT	25606	
ge9	No	111.111.111.111	44	-	No	LSP_DEFAULT	26263	
9.0.0.10	,label	25642)						(via
sa3000	No	18.0.0.10	11	-	Yes	LSP_DEFAULT	25606	
ge9	No	111.111.111.111	44	-	No	LSP_DEFAULT	26263	
9.0.0.10	,label	25642)						(via
L>	44.44.44.44/32	5	31 (e)					
sa3000.1001	No	18.0.1.10	7	-	Yes	LSP_DEFAULT	3	
sa3000	No	18.0.0.10	8	-	No	LSP_DEFAULT	3	
sa3000	No	18.0.0.10	8	-	Yes	LSP_DEFAULT	3	
sa3000.1001	No	18.0.1.10	7	-	No	LSP_DEFAULT	3	

```

L> 111.111.111.111/32 6 73 (e)
xe14.1001 Yes 15.0.1.10 71 - Yes LSP_DEFAULT 25622
ge9 Yes 9.0.0.10 36 - No LSP_DEFAULT 25642
xe14.1002 Yes 15.0.0.10 72 - Yes LSP_DEFAULT 25622
ge9 Yes 9.0.0.10 36 - No LSP_DEFAULT 25642
ge9 Yes 9.0.0.10 36 - Yes LSP_DEFAULT 25642
sa3000 Yes 18.0.0.10 17 - No LSP_DEFAULT 25614
sa3000.1001 Yes 18.0.1.10 16 - Yes LSP_DEFAULT 25614
ge9 Yes 9.0.0.10 36 - No LSP_DEFAULT 25642
sa3000 Yes 18.0.0.10 17 - Yes LSP_DEFAULT 25614
ge9 Yes 9.0.0.10 36 - No LSP_DEFAULT 25642
B> 120::/64 7 23 - - LSP_DEFAULT 25665
- No 111.111.111.111
PE2#

```

PE2#show interface counters rate mbps

Interface	Rx mbps	Rx pps	Tx mbps	Tx pps
ge4	0.00	0	0.00	0
ge5	240.28	3327	210.29	2913
ge6	0.00	0	0.00	0
ge7	260.29	3603	190.27	2635
ge9	250.29	3466	190.22	2635
ge10	0.00	0	0.00	0
sa3000	500.58	6930	400.56	5548
sa3000.1001	0.00	0	200.33	2774
xe12	997.83	13858	997.83	13858
xe12.400	997.83	13858	997.83	13858
xe14	250.40	3468	410.66	5685
xe14.1001	0.00	1	58.53	811
xe14.1002	250.40	3467	200.33	2772

PE2#

CHAPTER 9 LDP Graceful Restart

LDP graceful restart (GR) minimizes the negative effects on MPLS traffic caused by control-plane restarts in Label Switching Routers (LSR), especially by the restart of the Label Distribution Protocol (LDP).

LDP graceful restart enables a router whose LDP control plane is undergoing a restart to continue forwarding traffic while recovering its state from neighboring routers. This requires a restarting LDP router that retains established LSP labels. In helper mode, the router maintains label bindings as stale and reprocesses them, after the router undergoing graceful restart reestablishes its LDP session.

The MPLS forwarding state, which is the minimum state required to avoid any disturbance to LSPs traversing a restarting LSR, is preserved during the restart. This mechanism does not require any of the LDP-related states to be preserved across the restart. This means that when LDP restarts, there are minimal or no changes made to the forwarding table entries, and MPLS forwarding continues uninterrupted. This supports Graceful Restart in restarting routers as well as in neighbor routers.

Topology

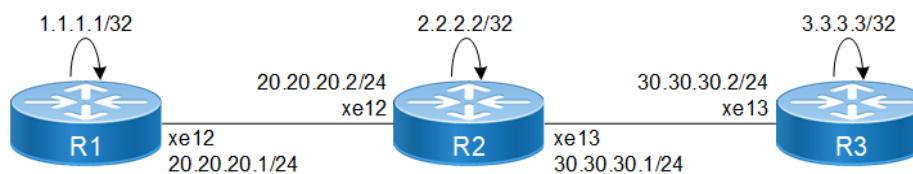


Figure 9-10: LDP Graceful Restart

Configuration

R1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter Interface mode for loopback.
(config-if)# ip address 1.1.1.1/32 secondary	Assign secondary IP address.
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)# router ldp	Enter the Router LDP mode
(config-router)# router-id 1.1.1.1	Assign router id for LDP
(config-router)# graceful-restart full	Enable graceful restart in LDP configure mode
(config-router)# graceful-restart timers neighbor-liveness 130	Configuring graceful neighbor-liveness timer to 130 sec.
(config-router)# graceful-restart timers max-recovery 150	Configuring graceful max recovery timer to 150 sec
(config-router)# exit	Exit Router LDP mode and return to Configure mode.
(config)#interface ce49	Enter Interface mode for ce49.
(config-if)# ip address 20.20.20.1/24	Assign IP address on ce49 interface.
(config-if)# enable-ldp ipv4	Enable LDP on the interface.
(config-if)# label-switching	Enable Label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.

(config)# router ospf	Enter the Router OSPF mode
(config-router)# network 1.1.1.1/32 area 0.0.0.0	Advertise loopback address in OSPF
(config-router)# network 20.20.20.0/24 area 0.0.0.0	Advertise network address in OSPF
(config-router)# redistribute connected	Configure redistribution connected.
(config-router)#exit	Exit from Router OSPF mode and enter into config mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#exit	Exit from configuration mode

R2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter Interface mode for loopback.
(config-if)# ip address 2.2.2.2/32 secondary	Assign secondary IP address.
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)# router ldp	Enter the Router LDP mode
(config-router)# router-id 2.2.2.2	Assign router id for LDP
(config-router)# graceful-restart helper-only	Enable graceful restart helper in LDP configure mode
(config-router)# exit	Exit Router LDP mode and return to Configure mode.
(config)#interface ce0	Enter Interface mode for ce0.
(config-if)# ip address 20.20.20.2/24	Assign IP address on ce0 interface.
(config-if)# enable-ldp ipv4	Enable LDP on the interface.
(config-if)# label-switching	Enable Label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe13	Enter Interface mode for xe13.
(config-if)# ip address 30.30.30.1/24	Assign IP address on xe13 interface.
(config-if)# enable-ldp ipv4	Enable LDP on the interface.
(config-if)# label-switching	Enable Label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)# router ospf	Enter the Router OSPF mode
(config-router)# network 2.2.2.2/32 area 0.0.0.0	Advertise loopback address in OSPF
(config-router)# network 20.20.20.0/24 area 0.0.0.0	Advertise network address in OSPF
(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF
(config-router)#exit	Exit from Router OSPF mode and enter into config mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#exit	Exit from configuration mode

R3

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter Interface mode for loopback.
(config-if)# ip address 3.3.3.3/32 secondary	Assign secondary IP address.
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)# router ldp	Enter the Router LDP mode
(config-router)# router-id 3.3.3.3	Assign router id for LDP
(config-router)# graceful-restart helper-only	Enable graceful restart helper in LDP configure mode
(config-router)# exit	Exit Router LDP mode and return to Configure mode.
(config)#interface xe13	Enter Interface mode for xe13.
(config-if)# ip address 30.30.30.2/24	Assign IP address on xe13 interface.
(config-if)# enable-ldp ipv4	Enable LDP on the interface.
(config-if)# label-switching	Enable Label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)# router ospf	Enter the Router OSPF mode
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Advertise loopback address in OSPF
(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF
(config-router)# redistribute connected	Configure redistribution connected.
(config-router)#exit	Exit from Router OSPF mode and enter into config mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#exit	Exit from configuration mode

Validation**R1****Before LDP Graceful Restart:**

```

RTR1#show running-config ldp
!
router ldp
 graceful-restart full
 graceful-restart timers neighbor-liveness 130
 graceful-restart timers max-recovery 150
!
!
interface ce49
 enable-ldp ipv4
!
RTR1#show ldp session
Peer IP Address          IF Name    My Role    State    KeepAlive  UpTime

```

```
2.2.2.2          ce49          Passive    OPERATIONAL    30    01:00:10
```

```
RTR1#show mpls ldp parameter
```

```
Router ID           : 1.1.1.1
LDP Version         : 1
Global Merge Capability : Merge Capable
Label Advertisement Mode : Downstream Unsolicited
Label Retention Mode  : Liberal
Label Control Mode    : Independent
Instance Loop Detection : Off
Request Retry         : Off
Propagate Release     : Disabled
Graceful Restart      : Enabled
Hello Interval        : 5
Targeted Hello Interval : 15
Hold time             : 15
Targeted Hold time    : 45
Keepalive Interval    : 10
Keepalive Timeout     : 30
Request retry Timeout : 5
Neighbor liveness Time : 130
Max recovery Time     : 150
Transport Address data :
  Labelspace 0        : 1.1.1.1 (in use)
Import BGP routes     : No
```

```
RTR1#show mpls forwarding-table
```

```
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport
```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L>	2.2.2.2/32	1	1	-	-	LSP_DEFAULT	3
ce49	No	20.20.20.2					
L>	3.3.3.3/32	2	2	-	-	LSP_DEFAULT	24321
ce49	No	20.20.20.2					
L>	30.30.30.0/24	3	1	-	-	LSP_DEFAULT	3
ce49	No	20.20.20.2					

```
RTR1#
```

```
Steps for LDP Graceful Restart:
```

```
RTR1#write
```

```
Building configuration...
```

```
2021 Sep 28 12:54:36.418 : RTR1 : CML : INFO : [CML_5]: Copy-config requested by client '82'
```

```
[OK]
```

```
RTR1#restart ldp graceful
```

Validation after Graceful Restart:

```
RTR1#show mpls forwarding-table
```

```
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport
```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
L> p 2.2.2.2/32		1	1	-	-	LSP_DEFAULT	3
ce49	No p 20.20.20.2						
L> p 3.3.3.3/32		2	2	-	-	LSP_DEFAULT	24321
ce49	No p 20.20.20.2						
L> p 30.30.30.0/24		3	1	-	-	LSP_DEFAULT	3
ce49	No p 20.20.20.2						

```
RTR1#show nsm ldp forwarding-timer
```

Protocol-Name	GR-State	Time Remaining (sec)	Disconnected-time
LDP	ACTIVE	118	2021/09/28 12:54:47

```
RTR1#
```

```
RTR1#show mpls ftn-table
```

```
Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
```

```
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
```

```
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
```

```
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
Out-segment with ix: 1, owner: N/A, Stale: YES, out intf: ce49, out label: 3
```

```
Nexthop addr: 20.20.20.2 cross connect ix: 1, op code: Push
```

```
Primary FTN entry with FEC: 3.3.3.3/32, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
```

```
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
```

```
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
```

```
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
Out-segment with ix: 2, owner: LDP, Stale: YES, out intf: ce49, out label: 24321
```

```
Nexthop addr: 20.20.20.2 cross connect ix: 2, op code: Push
```

```
Primary FTN entry with FEC: 30.30.30.0/24, id: 3, row status: Active, Tunnel-Policy: N/A
```

```
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
```

```
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
```

```
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
```

```
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
Out-segment with ix: 1, owner: N/A, Stale: YES, out intf: ce49, out label: 3
```

```
Nexthop addr: 20.20.20.2 cross connect ix: 1, op code: Push
```

```

RTR1#ping 3.3.3.3
Press CTRL+C to exit
PING 3.3.3.3 (3.3.3.3) 56(84) bytes of data.
64 bytes from 3.3.3.3: icmp_seq=1 ttl=64 time=0.540 ms
64 bytes from 3.3.3.3: icmp_seq=2 ttl=64 time=0.539 ms
64 bytes from 3.3.3.3: icmp_seq=3 ttl=64 time=0.491 ms
64 bytes from 3.3.3.3: icmp_seq=4 ttl=64 time=0.501 ms

--- 3.3.3.3 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 69ms
rtt min/avg/max/mdev = 0.491/0.517/0.540/0.035 ms
RTR1#ping 30.30.30.2
Press CTRL+C to exit
PING 30.30.30.2 (30.30.30.2) 56(84) bytes of data.
64 bytes from 30.30.30.2: icmp_seq=1 ttl=64 time=0.519 ms
64 bytes from 30.30.30.2: icmp_seq=2 ttl=64 time=0.540 ms
64 bytes from 30.30.30.2: icmp_seq=3 ttl=64 time=0.549 ms

--- 30.30.30.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 39ms
rtt min/avg/max/mdev = 0.519/0.536/0.549/0.012 ms

```

ROUTER-2

```

RTR2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code      FEC              FTN-ID   Nhlfe-ID  Tunnel-id  Pri   LSP-Type   Out-Label
Out-Intf   ELC   Nexthop
  L> p 1.1.1.1/32          1         1         -         -     LSP_DEFAULT 3
ce0        No    p 20.20.20.1
  L> 3.3.3.3/32           2         2         -         -     LSP_DEFAULT 3
xe13      No    30.30.30.2
RTR2#

```

```

After Restarting LDP processes:
root@RTR1:/home/ocnos# cd /usr/local/sbin/
root@RTR1:/usr/local/sbin# ./ldpd -d

```

```

RTR1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
        B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

```

```

Code      FEC      FTN-ID  Nhlfe-ID  Tunnel-id  Pri  LSP-Type  Out-Label
Out-Intf  ELC  Nexthop
  L>  2.2.2.2/32      1      1      -      -  LSP_DEFAULT  3
ce49      No  20.20.20.2
  L>  3.3.3.3/32      2      2      -      -  LSP_DEFAULT 24321
ce49      No  20.20.20.2
  L>  30.30.30.0/24    3      1      -      -  LSP_DEFAULT  3
ce49      No  20.20.20.2
RTR1#

```

```
RTR2#show mpls forwarding-table
```

```

Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

```

```

Code      FEC      FTN-ID  Nhlfe-ID  Tunnel-id  Pri  LSP-Type  Out-Label
Out-Intf  ELC  Nexthop
  L>  1.1.1.1/32      1      1      -      -  LSP_DEFAULT  3
ce0      No  20.20.20.1
  L>  3.3.3.3/32      2      2      -      -  LSP_DEFAULT  3
xe13      No  30.30.30.2
RTR2#

```

CHAPTER 10 LDP Tunneling over RSVP-TE

Overview

LDP-over-RSVP-TE tunneling is a technique used in MPLS networks to combine the strengths of Label Distribution Protocol (LDP) and Resource Reservation Protocol Traffic Engineering (RSVP-TE). This approach allows LDP Label Switched Paths (LSPs) to be encapsulated within RSVP-TE LSPs, providing enhanced traffic engineering capabilities while maintaining operational simplicity.

Feature Characteristics

LDP-over-RSVP-TE facilitates the integration of LDP LSPs within RSVP-TE tunnels, leveraging the strengths of both protocols. It harnesses RSVP-TE's traffic engineering capabilities for path computation, bandwidth reservation, and quality of service (QoS) provisioning. Ingress nodes execute FEC resolution to designate the suitable RSVP-TE tunnel for tunneling LDP LSPs, establishing hierarchical LSPs with RSVP-TE as the outer label and LDP as the inner label.

Benefits

LDP-over-RSVP-TE offers significant benefits are:

- **Advanced Traffic Engineering:** By leveraging RSVP-TE's advanced traffic engineering mechanisms, LDP-over-RSVP-TE enables efficient path computation, bandwidth reservation, and Quality of Service (QoS) provisioning.
- **Simplified Network Topology:** eliminates the need for a full mesh of intra-area RSVP LSPs (Label Switched Paths) between PE (Provider Edge) nodes.
- **Enhanced Resilience with Fast Reroute (FRR):** Inherit RSVP-TE's Fast Reroute (FRR) capabilities. This means that in case of link or node failures, the network can quickly reroute traffic along pre-established backup paths
- **Flexible Hierarchical LSP Design:** Provides flexibility in network design by allowing for hierarchical LSPs (Label Switched Paths) where RSVP-TE serves as the outer label and LDP as the inner label.

Prerequisites

Before configuring this feature, ensure the following:

- A functional MPLS network with support for both LDP and RSVP-TE protocols.
- Network devices (routers or switches) capable of supporting LDP and RSVP-TE functionalities.

Limitations

The limitations are:

- LDP-over-RSVP tunneling is supported only with ISIS as IGP.
- Tunneling over inter-domain IGP area is not supported.
- LDP LSP tunneling over RSVP multipath is not supported.
- MPLS trace route is not supported in LDP-over-RSVP tunneling path.
- Dynamic TLDP sessions are not supported, TLDP session has to be explicitly configured.

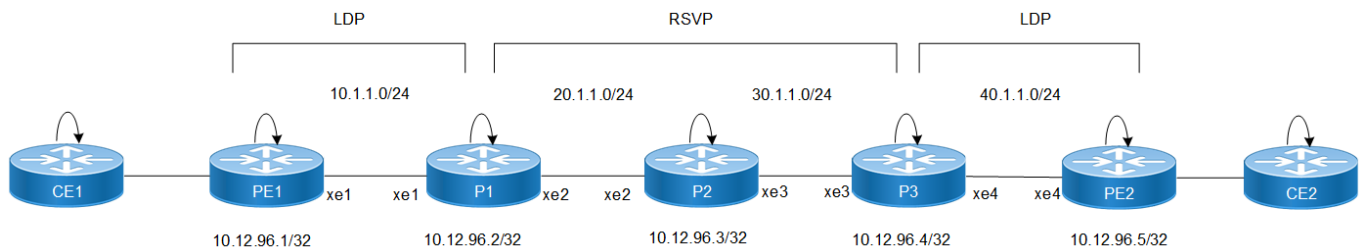
- LFA and/or RLFA protection is not supported for LDP-over-RSVP tunnels.
- MPLS EVPN ELAN services over LoR are not supported.

Configuration for LDP Tunneling Over RSVP

Configure various nodes within the topology to set up a LDP Tunneling over RSVP session.

Topology

This sample topology provides basic connectivity and routing between the devices.



LDP Tunneling over RSVP Configuration

Configure LDP Tunneling over RSVP on PE1 Router

Follow the steps to configure the LDP tunneling over RSVP on PE1 router:

1. Configure the loopback interface with an IP address.

```
PE1(config)#interface lo
PE1(config-if)#ip address 10.12.96.1/32 secondary
```
2. Configure the global LDP parameters including the router ID and transport address.

```
PE1(config)#router ldp
PE1(config-router)#router-id 10.12.96.1
PE1(config-router)#transport-address ipv4 10.12.96.1
```
3. Configure global RSVP parameters.

```
PE1(config)#router rsvp
```
4. Configure the interface facing the network side with an IP address, enable label switching, and enable LDP.

```
PE1(config)#interface xe1
PE1(config-if)#ip address 10.1.1.1/24
PE1(config-if)#label-switching
PE1(config-if)#enable-ldp ipv4
```
5. If using ISIS as the Interior Gateway Protocol (IGP), configure ISIS parameters including traffic engineering.

```
PE1(config)#router isis ISIS-IGP
PE1(config-router)#is-type level-1
PE1(config-router)#metric-style wide
PE1(config-router)#mpls traffic-eng router-id 10.12.96.1
PE1(config-router)#mpls traffic-eng level-1
PE1(config-router)#capability cspf
PE1(config-router)#dynamic-hostname
PE1(config-router)#net 49.0000.0000.0001.00
```

```
PE1(config-router)#exit
```

Configure LDP Tunneling over RSVP on P1 Router

Follow the steps to configure the LDP tunneling over RSVP on P1 router:

1. Configure the loopback interface with an IP address.


```
P1(config)#interface lo
P1(config-if)# ip address 10.12.96.2/32 secondary
```
2. Configure the global TLDP parameters including the router ID and transport address.


```
P1(config)#router ldp
P1(config-router)#router-id 10.12.96.2
P1(config-router)# targeted-peer ipv4 10.12.96.4
P1(config-router-targeted-peer)#exit
P1(config-router)# transport-address ipv4 10.12.96.2
```
3. Configure LDP to prefer tunneling over RSVP.


```
P1(config)#router ldp
P1(config-router)# prefer-tunnel-in-tunnel rsvp
```
4. Configure global RSVP parameters.


```
P1(config)#router rsvp
```
5. Configure a RSVP trunk towards the neighbor router (assuming 10.12.96.4 is the neighbor) and enable ldp-tunneling to allow tunneling LDP LSPs.


```
P1(config)# rsvp-trunk t1 ipv4
P1(config-trunk)#to 10.12.96.4
P1(config-trunk)#ldp-tunneling
```
6. Configure the interface facing the network side with an IP address, enable label switching, and enable LDP and RSVP.
 - For interface xe1:


```
P1(config)#interface xe1
P1(config-if)#ip address 10.1.1.2/24
P1(config-if)#label-switching
P1(config-if)#enable-ldp ipv4
```
 - For interface xe2:


```
P1(config)#interface xe2
P1(config-if)#ip address 20.1.1.1/24
P1(config-if)#label-switching
P1(config-if)#enable-rsvp
```
7. If using ISIS as the Interior Gateway Protocol (IGP), configure ISIS parameters including traffic engineering.


```
P1(config)#router isis ISIS-IGP
P1(config-router)#is-type level-1
P1(config-router)#metric-style wide
P1(config-router)#mpls traffic-eng router-id 10.12.96.2
P1(config-router)#mpls traffic-eng level-1
P1(config-router)#capability cspf
P1(config-router)#dynamic-hostname
P1(config-router)#net 49.0000.0000.0002.00
P1(config-router)#exit
```

Configure LDP Tunneling over RSVP on P2 Router

Follow the steps to configure the LDP tunneling over RSVP on P2 router:

1. Configure the loopback interface with an IP address.

```
P2(config)#interface lo
P2(config-if)# ip address 10.12.96.3/32 secondary
```
2. Configure the global LDP parameters including the router ID and transport address.

```
P2(config)#router ldp
P2(config-router)#router-id 10.12.96.3
P2(config-router)# transport-address ipv4 10.12.96.3
```
3. Configure global RSVP parameters.

```
P2(config)#router rsvp
```
4. Configure the interface facing the network side with an IP address, enable label switching, and enable RSVP.
 - For interface xe2:

```
P2(config)#interface xe2
P2(config-if)#ip address 20.1.1.2/24
P2(config-if)#label-switching
P2(config-if)#enable-rsvp
```
 - For interface xe3:

```
P2(config)#interface xe3
P2(config-if)#ip address 30.1.1.1/24
P2(config-if)#label-switching
P2(config-if)#enable-rsvp
```
5. If using ISIS as the Interior Gateway Protocol (IGP), configure ISIS parameters including traffic engineering.

```
P2(config)#router isis ISIS-IGP
P2(config-router)#is-type level-1
P2(config-router)#metric-style wide
P2(config-router)#mpls traffic-eng router-id 10.12.96.3
P2(config-router)#mpls traffic-eng level-1
P2(config-router)#capability cspf
P2(config-router)#dynamic-hostname
P2(config-router)#net 49.0000.0000.0003.00
P2(config-router)#exit
```

Configure LDP Tunneling over RSVP on P3 Router

Follow the steps to configure the LDP tunneling over RSVP on P3 router:

1. Configure the loopback interface with an IP address.


```
P3(config)#interface lo
P3(config-if)# ip address 10.12.96.4/32 secondary
```
2. Configure the global LDP parameters including the router ID and transport address.


```
P3(config)#router ldp
P3(config-router)#router-id 10.12.96.4
P3(config-router)# targeted-peer ipv4 10.12.96.2
P3(config-router-targeted-peer)#exit
P3(config-router)# transport-address ipv4 10.12.96.4
```
3. Configure global RSVP parameters.


```
P3(config)#router rsvp
```
4. Configure prefix lists.


```
P3(config)# ip prefix-list fec_list
P3(config-ip-prefix-list)# seq 5 permit 10.12.96.5/32
P3(config)# ip prefix-list peer_list
P3(config-ip-prefix-list)# seq 5 permit 10.12.96.2/32
```
5. Configure prefix lists to control label advertisement between peers.


```
P3(config)# router ldp
P3(config-router)# advertise-labels for fec_list to peer_list
```
6. Configure the interface facing the network side with an IP address, enable label switching, and enable RSVP.
 - For interface xe3:


```
P3(config)#interface xe3
P3(config-if)#ip address 30.1.1.2/24
P3(config-if)#label-switching
P3(config-if)#enable-rsvp
```
 - For interface xe4:


```
P3(config)#interface xe4
P3(config-if)#ip address 40.1.1.1/24
P3(config-if)#label-switching
P3(config-if)#enable-ldp ipv4
```
7. If using ISIS as the Interior Gateway Protocol (IGP), configure ISIS parameters including traffic engineering.


```
P3(config)#router isis ISIS-IGP
P3(config-router)#is-type level-1
P3(config-router)#metric-style wide
P3(config-router)#mpls traffic-eng router-id 10.12.96.4
P3(config-router)#mpls traffic-eng level-1
P3(config-router)#capability cspf
P3(config-router)#dynamic-hostname
P3(config-router)#net 49.0000.0000.0004.00
P3(config-router)#exit
```

Configure LDP Tunneling over RSVP on PE2 Router

Follow the steps to configure the LDP tunneling over RSVP on PE2 router:

1. configure the loopback interface with an IP address.

```
PE2(config)#interface lo
PE2(config-if)# ip address 10.12.96.5/32 secondary
```
2. Configure the global LDP parameters including the router ID and transport address.

```
PE2(config)#router ldp
PE2(config-router)#router-id 10.12.96.5
PE2(config-router)# transport-address ipv4 10.12.96.5
```
3. Configure the interface facing the network side with an IP address, enable label switching, and enable LDP.

```
PE2(config)#interface xe4
PE2(config-if)#ip address 40.1.1.2/24
PE2(config-if)#label-switching
PE2(config-if)#enable-ldp ipv4
```
4. If using ISIS as the Interior Gateway Protocol (IGP), configure ISIS parameters including traffic engineering.

```
PE2(config)#router isis ISIS-IGP
PE2(config-router)#is-type level-1
PE2(config-router)#metric-style wide
PE2(config-router)#mpls traffic-eng router-id 10.12.96.5
PE2(config-router)#mpls traffic-eng level-1
PE2(config-router)#capability cspf
PE2(config-router)#dynamic-hostname
PE2(config-router)#net 49.0000.0000.0005.00
PE2(config-router)#exit
```

Snippet Configuration on P1 Router

Follow the steps to configure the LDP tunneling over RSVP on P1 router using snippet:

```
P1#show running-config isis
!
!
router isis ISIS-IGP-100
 is-type level-1
 metric-style wide
 mpls traffic-eng router-id 10.12.96.2
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 net 49.0001.0000.0000.0002.00
!

P1#show running-config ldp
!
router ldp
 router-id 10.12.96.2
 prefer-tunnel-in-tunnel rsvp
 targeted-peer ipv4 10.12.96.4
  exit-targeted-peer-mode
 transport-address ipv4 10.12.96.2
!
```

```

interface xe1
  enable-ldp ipv4

P1#show running-config rsvp
!
router rsvp
!
!
interface xe2
  enable-rsvp
!
!
rsvp-trunk t1 ipv4
  to 10.12.96.4
  ldp-tunneling
!

```

Snippet Configuration on P3 Router

Follow the steps to configure the LDP tunneling over RSVP on P3 router using snippet:

```

P3#show running-config ldp
!
router ldp
  targeted-peer ipv4 10.12.96.2
  exit-targeted-peer-mode
  transport-address ipv4 10.12.96.4
  advertise-labels for fec_list to peer_list
!
interface xe4
  enable-ldp ipv4
!

```

Validation

Validation on P1 node:

```

P1#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

```

Code	Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
	10.12.96.1	xe1	Active	OPERATIONAL	30	00:05:42
	10.12.96.4	xe2	Passive	OPERATIONAL	30	00:05:44

```

P1#
P1#
P1#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
indicates the session is active with local repair at one or more nodes

```

(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:

To	From	Tun-ID	LSP-ID	Type	LSPName	
State	Uptime	Rt	Style	Labelin	Labelout	
10.12.96.4	10.12.96.2	5001	2201	PRI	t1-Primary	UP
00:01:15	1 1 SE	-	25600			

Total 1 displayed, Up 1, Down 0.

P1#

P1#

P1#

P1#show mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
 B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
 L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
 (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-Intf
ELC	Nexthop	UpTime					
L>	10.12.96.1/32	2	39	-	-	-	-
-	00:31:26		38	-	Yes	3	xe1
No	10.1.1.1	-					
R(t)>	10.12.96.4/32	1	9	5001	Yes	25600	xe2
No	22.1.1.1	00:01:19					
L>	10.12.96.5/32	3	11	-	-	-	-
-	00:01:19		10	-	Yes	26244	No

(via rsvp tunnel-id 5001, nhlfe_ix 9, label 25600)

P1#

P1#

P1#

P1#show ldp tunneling

Tunnel Name : t1
 Tunnel Endpoint : 10.12.96.4/32
 Tunnel Cost : 20
 Tunnel Owner : RSVP
 Tunnel Status : Up

FEC	Upstream-Peer	In-Label	Out-Label
10.12.96.5/32	10.12.96.1	26242	26244

Total FEC tunneled by t1 : 1

P1#

```
P1#
P1#show ldp tunneling-fec
FEC          Tunnel-name          Tunnel-endpoint    Upstream-Peer    In-
label  Out-label
=====
10.12.96.5/32  t1          10.12.96.4/32    10.12.96.1      26242
26244
```

Total LDP Tunneled FEC : 1

P1#

P1#

P1#

P1#

P1#sh ldp tunneling-tunnels

```
Tunnel-name          Tunnel-endpoint    Status    Cost
=====
t1          10.12.96.4/32    Up        20
```

CLI Commands for LDP Tunneling over RSVP-TE

The LDP Tunneling over RSVP-TE introduces the following configuration commands.

ldp-tunneling

Use this command to enable LDP tunneling over RSVP trunk. When a specific RSVP trunk is enabled for tunneling, user traffic is tunneled using LDP LSP over RSVP LSP. If more than one trunk is enabled for tunneling LDP LSP, following trunk selection method is followed:

- If there are more than one trunk with same tunnel end-node, trunk with best metric (lower cost) is selected.
- If a destination FEC is reachable via more than one tunnel-endpoint, a tunnel-endpoint which is closer to destination is selected for tunneling.

Note: TLDP sessions should be manually established with RSVP tunnel end-nodes. Additionally, the 'advertise-labels' CLI must be explicitly configured to permit label advertisement over TLDP sessions.

Use `no` parameter of this command to disable tunneling from a trunk.

Command Syntax

```
ldp-tunneling
no ldp-tunneling
```

Parameters

None

Default

Disabled

Command Mode

rsvp-trunk mode

Applicability

Introduced in OcNOS version 6.5.2.

Example

The following example describes how to enable LDP tunneling over RSVP trunk:

```
OcNOS#configure terminal
OcNOS(config)#rsvp-trunk t2
OcNOS(config-trunk)#to 4.4.4.4
OcNOS(config-trunk)#ldp-tunneling
OcNOS(config-trunk)#commit
OcNOS(config-trunk)#end
```

prefer-tunnel-in-tunnel rsvp

Use this command for prioritizing RSVP trunk over LDP-LSP for forwarding LDP traffic. By default incoming LDP traffic is forwarded using LDP LSP. However when this CLI is configured and if RSVP trunk has been enabled for tunneling LDP LSP, user data (incoming LDP LSP) is tunneled over RSVP tunnels. If this CLI is not enabled and RSVP trunk has been enabled for tunneling LDP LSP, user data still can be forwarded over RSVP trunk if no LDP LSP exist.

Use `no` parameter of this command to prioritizing LDP-LSP over RSVP trunk while forwarding LDP traffic.

Command Syntax

```
prefer-tunnel-in-tunnel rsvp
no prefer-tunnel-in-tunnel rsvp
```

Parameters

None

Default

LDP-LSP is selected over RSVP trunks for forwarding.

Command Mode

Router LDP mode

Applicability

Introduced in OcNOS version 6.5.2.

Example

The following example describes how to prioritize RSVP trunk over LDP-LSP for forwarding LDP traffic:

```
OcNOS#configure terminal
OcNOS(config)#router ldp
OcNOS(config-router)#prefer-tunnel-in-tunnel rsvp
OcNOS(config-router)#commit
OcNOS(config-router)#end
```

Show Commands for LDP Over RVSP

show ldp tunneling fec

This command displays the LDP tunneling FEC mappings.

Command Syntax

```
show ldp tunneling-fec
```

Parameters

None

Command Mode

EXEC mode

Applicability

Introduced in OcNOS version 6.5.2.

Example

The following configuration illustrates how to view the FEC mappings on router R2:

```
R2#show ldp tunneling-fec
FEC                               Tunnel-name      Tunnel-endpoint
Upstream-Peer   In-label  Out-label
52.1.1.0/24      t2
26253           26250      4.4.4.4/32      1.1.1.1
53.1.1.0/24      t2
26255           26241      4.4.4.4/32      1.1.1.1

Total LDP Tunneled FEC : 2
```

show ldp tunneling

This command displays the LDP tunneling.

Command Syntax

```
show ldp tunneling
```

Parameters

None

Command Mode

EXEC mode

Applicability

Introduced in OcNOS version 6.5.2.

Example

The following example describes how to view the LDP tunneling on router R2:

```
Tunnel Name      : t1
```



```
Tunnel Endpoint      : 10.12.96.4/32
Tunnel Cost          : 20
Tunnel Owner         : RSVP
Tunnel Status        : Up
```

```
FEC                  Upstream-Peer    In-Label    Out-Label
=====
10.12.96.5/32        10.12.96.1    26242      26244
```

```
Total FEC tunneled by t1 : 1
```

show ldp tunneling-tunnels.

This command displays the LDP tunneling tunnels.

Command Syntax

```
show ldp tunneling-tunnels
```

Parameters

None

Command Mode

EXEC mode

Applicability

Introduced in OcNOS version 6.5.2.

Example

The following example describes how to view the LDP tunneling on router R2:

```
R2#show ldp tunneling-tunnels
Tunnel-name      Tunnel-endpoint    Status    Cost
t2               4.4.4.4/32        Up        20
```

Glossary

Note: List key terms used in this document and add the term and explanation to our existing Glossary.

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
Forward Error Correction (FEC)	A system of error control that allows the receiver to correct some errors without having to request a re-transmission of data.
Interior Gateway Protocol (IGP)	An intradomain protocol used to exchange network reachability and routing information among devices within an autonomous system (AS), such as Intermediate System to Intermediate System (IS-IS), Open Shortest Path First (OSPF), or Routing Information Protocol (RIP). Contrast with Exterior Gateway Protocol (EGP).

Label Distribution Protocol (LDP)	A protocol for distributing labels in non-traffic-engineered applications. LDP allows routers to create label-switched path (LSP) instances through a network by mapping network layer routing information directly to data-link layer switched paths.
Resource Reservation Protocol (RSVP)	A signaling protocol for reserving resources across a network. RSVP is rarely used by itself, but Resource Reservation Protocol—Traffic Engineering (RSVP-TE) is widely used.
Targeted Label Distribution Protocol (TLDP)	A specialized form of LDP (Label Distribution Protocol) sessions.

Label Distribution Protocol Command Reference

CHAPTER 1 LDP Commands

This chapter is a reference for the LDP commands:

- [advertise-labels](#)
- [advertise-label-for-default-route](#)
- [advertisement-mode](#)
- [auto-targeted-session](#)
- [clear ldp adjacency](#)
- [clear ldp session](#)
- [clear ldp statistics](#)
- [clear ldp statistics advertise-labels](#)
- [control-mode](#)
- [debug ldp advertise-labels](#)
- [debug ldp all](#)
- [debug ldp dsm](#)
- [debug ldp events](#)
- [debug ldp fsm](#)
- [debug ldp hexdump](#)
- [debug ldp inter-area](#)
- [debug ldp nsm](#)
- [debug ldp packet](#)
- [debug ldp usm](#)
- [debug ldp vc usm](#)
- [disable-ldp](#)
- [enable-ldp](#)
- [explicit-null](#)
- [fast-reroute](#)
- [global-merge-capability](#)
- [graceful-restart](#)
- [hello-interval](#)
- [hold-time](#)
- [import-bgp-routes](#)
- [inter-area-lsp](#)
- [keepalive-interval](#)
- [label-retention-mode](#)
- [ldp advertisement-mode](#)
- [targeted-peer hello-interval](#)
- [targeted-peer hold-time](#)

- [targeted-peer tunneling](#)
- [ldp hello-interval](#)
- [ldp hold-time](#)
- [ldp keepalive-interval](#)
- [ldp keepalive-timeout](#)
- [ldp label-retention-mode](#)
- [ldp multicast-hellos](#)
- [ldp-optimization](#)
- [loop-detection](#)
- [loop-detection-hop-count](#)
- [loop-detection-path-vec-count](#)
- [mpls ldp-igp sync isis](#)
- [mpls ldp-igp sync ospf](#)
- [mpls ldp-igp sync-delay](#)
- [neighbor](#)
- [neighbor tcp-mss](#)
- [propagate-release](#)
- [pw-status-tlv](#)
- [request-labels-for](#)
- [request-retry](#)
- [request-retry-timeout](#)
- [restart ldp graceful](#)
- [rlfa-ilm-optimization](#)
- [router ldp](#)
- [router-id](#)
- [snmp restart ldp](#)
- [targeted-peer ipv4](#)
- [targeted-peer-hello-interval](#)
- [targeted-peer-hold-time](#)
- [transport-address ipv4](#)

advertise-labels

Use this command to prevent the distribution of any locally assigned labels.

Use the `no` parameter to enable the distribution of all locally assigned labels to all LDP neighbors.

Command Syntax

```
advertise-labels for any to none
advertise-labels for PREFIX to (PEER|any)
no advertise-labels for any to none
no advertise-labels for PREFIX to (PEER|any)
```

Parameters

<code>for</code>	Specify the permitted destinations
<code>any</code>	Specify to permit any locally assigned labels
<code>PREFIX</code>	Specify the destinations which have labels are advertised
<code>to</code>	Specify the given neighbor
<code>PEER</code>	Specify the LDP neighbors which receive these advertisements
<code>none</code>	Specify that there are no LDP neighbors

Default

The labels of all destinations are advertised to all LDP neighbors.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#advertise-labels for any to none

#configure terminal
(config)#router ldp
(config-router)#advertise-labels for PREFIX to any

#configure terminal
(config)#router ldp
(config-router)#advertise-labels for PREFIX to PEER
```

advertise-label-for-default-route

Use this command to enable label advertisement for default route.

Use `no` form to disable the label advertisement for default route.

Command Syntax

```
advertise-label-for-default-route
```

Parameters

None

Default

Disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 4.2.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#advertise-label-for-default-route
```

advertisement-mode

Use this command to set the label advertisement mode for all the interfaces for the current LSR. Specifying `downstream-on-demand` and `downstream-unsolicited` mode affects which LSR initiates mapping requests and mapping advertisements.

This command is a global command used to set the label advertisement mode for all interfaces for the current LSR. The advertisement mode set for a specific interface overrides the value set by this command (see `ldp advertisement-mode`). Use this command before starting the interface as it closes and restarts all sessions.

Use the `no` parameter to revert to the default advertisement mode value.

Command Syntax

```
advertisement-mode (downstream-on-demand|downstream-unsolicited)
no advertisement-mode (downstream-on-demand|downstream-unsolicited)
```

Parameters

`downstream-on-demand`

Sends label upon request. When a users uses this mode, a router distributes a label to a peer only if there is a pending label request from a peer. The reaction of the downstream router to this request depends on the label advertising mode supported on the next hop. This mode is typically used with the conservative label retention mode.

`downstream-unsolicited`

Sends label without waiting request. This mode distributes labels to peers without waiting for a label request, and is typically used with the liberal label retention mode.

Default

By default, advertisement mode is `downstream-unsolicited`

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

In the following example, the LSR will use the `downstream-unsolicited` advertisement mode for an LDP session on its interfaces.

```
#configure terminal
(config)#router ldp
(config-router)#advertisement-mode downstream-unsolicited
```

auto-targeted-session

Use this command at remote LFA node, to accept received targeted hello and allow creating TLDP session dynamically to establish rLFA tunnel. This command is used for remote LFA only.

Use the no parameter to disable dynamically TLDP session creation.

Dynamically created TLDP session can be deleted only when "auto-targeted-session" or "fast-reroute" configuration is removed.

Command Syntax

```
auto-targeted-session
no auto-targeted-session
```

Parameters

None

Command Mode

Router mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#router ldp
(config-router)#auto-targeted-session
(config-router)#
```

clear ldp adjacency

Use this command to clear an adjacency with a specified peer, or to clear all adjacencies for the current LSR.

Command Syntax

```
clear ldp adjacency (A.B.C.D|*)
```

Parameters

*	Specify to clear all adjacencies.
A.B.C.D	Specify to clear IPv4 address of the peer.

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#clear ldp adjacency 123.123.123.33
```

clear ldp session

Use this command to clear a session established with a specified peer, or to clear all sessions for the current LSR.

Command Syntax

```
clear ldp session (A.B.C.D|*)
```

Parameters

*	Specify to clear all sessions.
A.B.C.D	Specify to clear IPv4 address of the peer.

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#clear ldp session 123.123.123.33
```

clear ldp statistics

Use this command to clear LDP statistics. This command clears the count per each operation filtered by an advertisement list.

Command Syntax

```
clear ldp statistics
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#clear ldp statistics
```

clear ldp statistics advertise-labels

Use this command to clear LDP advertise-labels statistics. This command clears the count per each operation filtered by an advertisement list.

Command Syntax

```
clear ldp statistics advertise-labels
clear ldp statistics advertise-labels for PREFIX
clear ldp statistics advertise-labels for PREFIX to PEER
```

Parameters

advertise-labels	Specify the IP prefix list of advertise-labels.
for	Specify the permitted destinations.
PREFIX	Specify the destinations that have their labels advertised.
to	Specify the given neighbor.
PEER	Specify the LDP neighbors that receive these advertisements.

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#clear ldp statistics advertise-labels
```

control-mode

Use this command to set the control mode for label processing. Ordered processing sets the mode to strict chain-of-command; an LSR replies to a request packet from an LSR higher in the chain only after it receives a label from an LSR lower in the chain. Independent processing sets the mode to instant replies.

In independent control mode, each LSR might advertise label mappings to its neighbors at any time. In independent downstream-on-demand mode, an LSR might answer requests for label mappings immediately, without waiting for a label mapping from the next hop. In independent downstream unsolicited mode, an LSR might advertise a label mapping for an Forwarding Equivalence Class (FEC) to its neighbors whenever it is prepared to label-switch that FEC. In independent mode, an upstream label can be advertised before a downstream label is received.

In ordered control mode, an LSR may initiate the transmission of label mapping only for an FEC for which it has a label mapping for the FEC next hop, or for which the LSR is the egress. For each FEC for which the LSR is not the egress and no mapping exists, the LSR must wait until a label from a downstream LSR is received. An LSR may be an egress for some FECs and a non-egress for others. Changes in control mode only affect labels that were sent or received after the change was made.

Use the `no` parameter to revert to default control mode.

Note: Control mode "independent" is supported with advertisement mode "DU" only.

Note: When the advertisement mode is set as "DU", control mode automatically sets to "independent".

Note: Control mode "independent" is not supported with advertisement mode "DOD".

Note: Control mode "ordered" is supported with advertisement mode "DOD" only.

Note: Control mode "ordered" is not supported with advertisement mode "DU".

Note: When the advertisement mode is set as "DOD", control mode automatically sets to "ordered".

Command Syntax

```
control-mode (ordered|independent)
no control-mode
```

Parameters

<code>independent</code>	Sets control mode to independent processing.
<code>ordered</code>	Sets control mode to ordered processing.

Command Mode

Router mode

Default

By default, control mode is independent

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#control-mode ordered
```

debug ldp advertise-labels

Use this command to enable the debugging of LDP advertise-label events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp advertise-labels
no debug ldp advertise-labels
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp advertise-labels
```

debug ldp all

Use this command to enable the debugging of all LDP events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp all
no debug ldp all
no debug all
undebug all
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp all
```

debug ldp dsm

Use this command to enable the debugging of LDP DSM events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp dsm
no debug ldp dsm
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp dsm
```

debug ldp events

Use this command to enable the debugging of all LDP events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp events
no debug ldp events
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp advertise-labels
(config)#debug ldp all
(config)#debug ldp dsm
(config)#debug ldp events
```

debug ldp fsm

Use this command to enable the debugging of LDP FSM events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp fsm
no debug ldp fsm
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp fsm
```

debug ldp hexdump

Use this command to enable the debugging of LDP hexdump events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp hexdump
no debug ldp hexdump
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp hexdump
```

debug ldp inter-area

Use this command to enable the debugging of LDP inter-area events.

On using the debug command, the router continues to generate an output until the no parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the log syslog command in configure mode to redirect the debugging output to a file or the syslog.

Use the no parameter with this command to disable this function.

Command Syntax

```
debug ldp inter-area
no debug ldp inter-area
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 4.0.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp inter-area
```

debug ldp nsm

Use this command to enable the debugging of LDP NSM events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp nsm
no debug ldp nsm
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp nsm
```

debug ldp packet

Use this command to enable the debugging of LDP packet events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp packet
debug ldp packet (notification|hello|initialization|keepalive|address|label)
no debug ldp packet
no debug ldp packet (notification|hello|initialization|keepalive|address|label)
```

Parameters

<code>notification</code>	Debug LDP notification packets.
<code>hello</code>	Debug LDP hello packets.
<code>initialization</code>	Debug LDP initialization packets.
<code>keepalive</code>	Debug LDP keepalive packets.
<code>address</code>	Debug LDP address (withdraw) packets.
<code>label</code>	Debug LDP address label packets.

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp packet hello
```

debug ldp usm

Use this command to enable the debugging of LDP USM events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp usm
no debug ldp usm
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp usm
```

debug ldp vc usm

Use this command to enable the debugging of LDP VC events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp vc dsm
debug ldp vc usm
no debug ldp vc dsm
no debug ldp vc usm
```

Parameters

dsm	Debug LDP downstream SM.
usm	Debug LDP upstream SM.

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp vc dsm
(config)#debug ldp vc usm
```

disable-ldp

Use this command to disable LDP IPv4 on a specified interface.

This command disables the transmission of Hello packets through the current interface, and clears all created sessions and adjacencies for this interface. Use `disable-ldp` alone to disable only LDP IPv4 on the interface.

Command Syntax

```
disable-ldp (ipv4|)
```

Parameters

<code>ipv4</code>	Disables IPv4 on the interface.
-------------------	---------------------------------

Default

By default, disable ldp is disabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following example disables LDP IPv4 on interface eth0.

```
#configure terminal
(config)#interface eth0
(config-if)#disable-ldp
```

The following example disables LDP IPv4 on interface eth0.

```
#configure terminal
(config)#interface eth0
(config-if)#disable-ldp ipv4
```

enable-ldp

Use this command to enable LDP IPv4 on a specified interface. This command enables the transmission of Hello packets through the current interface, so that LDP adjacencies and LDP sessions can be created.

Note: The corresponding interface must be enabled for label-switching using the [label-switching](#) command.

Command Syntax

```
enable-ldp ipv4
```

Parameters

None

Default

By default, enable ldp is disabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following example enables LDP IPv4 on interface eth0.

```
#configure terminal
(config)#interface eth0
(config-if)#enable-ldp ipv4
```

explicit-null

Use this command to configure the router to send explicit-null labels for directly connected FECs instead of implicit-null labels. Implicit-nulls are the default labels.

This command controls the label value advertised on the egress router of an LSP. By default, implicit null label (label 3) is advertised for directly connected FECs. LDP advertises an Implicit Null label that causes the previous hop router to perform penultimate hop popping. Use the `explicit null` command to avoid the penultimate router from penultimate hop popping, and to force it to replace the incoming label with the explicit null label.

Note: Do not use this command if the LDP is concurrently used for MPLS/BGP VPNs.

Use the `no` parameter to stop sending explicit-null labels for directly connected FECs and resume sending implicit-null labels for them.

Command Syntax

```
explicit-null
no explicit-null
```

Parameters

None

Default

By default, sends implicit-null labels.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#explicit-null
```

fast-reroute

Use this command to enable the installation of backup paths advertised by IGP LFA (and/or rLFA) fast reroute.

Use no form CLI to disable the feature.

Command Syntax

```
fast-reroute
no fast-reroute
```

Parameters

None

Command Mode

Router mode

Applicability

This command was introduced in OcNOS version 5.1.

Examples

```
#configure terminal
(config)#router ldp
(config)#fast-reroute
```

global-merge-capability

Use this command to override the default merge capability setting of all the interfaces for the current LSR.

The merge capability aggregates multiple incoming flows with the same destination address into a single outgoing flow. This reduces the label-space shortage by sharing labels for different flows with the same destination, or the same FEC (Forwarding Equivalence Class).

Use the `no` parameter to revert to the default merge capability settings of all the interfaces for this LSR.

Command Syntax

```
global-merge-capability (merge-capable|non-merge-capable)
no global-merge-capability
```

Parameters

<code>merge-capable</code>	Maps all incoming labels that are destined for the same FEC to the same outgoing label (this is the Ethernet default.)
<code>non-merge-capable</code>	Maps all incoming labels, regardless of destination FEC to unique outgoing labels (this is the non-Ethernet default.)

Default

By default, global merge capability is merge capable.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#global-merge-capability merge-capable
```

graceful-restart

Use this command to enable the Graceful-Restart capability for LDP.

Use the `no` parameter to disable the GR capability for LDP.

Command Syntax

```
graceful-restart full
graceful-restart helper-only
graceful-restart timers max-recovery <15-600>
graceful-restart timers neighbor-liveness <5-300>
no graceful-restart
no graceful-restart timers max-recovery
no graceful-restart timers neighbor-liveness
```

Parameters

<code>full</code>	Configuring with full enable the complete GR capability
<code>helper-only</code>	Configuring with helper-only enables only helper mode
<code>timers</code>	Non-default recovery and reconnect timer values.
<code>max-recovery</code>	Maximum recovery time
<code><15-600></code>	Interval until which LDP preserves route after peer restart
<code>neighbor-liveness</code>	Neighbor Liveness Time
<code><5-300></code>	Hold timer for a targeted LDP peer

Default

GR capability is not enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 5.0.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#graceful-restart full
(config-router)#graceful-restart helper-only
(config-router)#graceful-restart timers max-recovery 100
(config-router)#graceful-restart timers neighbor-liveness 200
```

hello-interval

Use this command to set the interval after which `hello` packets are sent out.

LDP defines a mechanism for discovering adjacent Label Switching Routers (LSRs) that participate in label switching (adjacencies). Hello messages are sent to the All Routers Multicast Group (224.0.0.2). Whenever a new router comes up, it sends out a hello packet to a specified, multicast address announcing itself to the network. Every router directly connected to the network receives the packet. Receipt of a hello packet from another LSR creates a `hello adjacency` with that LSR. Use this command to specify the interval after which the hello packets will be sent.

Used as a global command, the `hello-interval` value may be overridden by the `hello-interval` set on the interface (see [ldp hello-interval](#)). For optimum performance, set this value to no more than one-third the value of the hold-time specified.

Use the `no` parameter to revert to default hello interval.

Command Syntax

```
hello-interval <1-21845>
no hello-interval
```

Parameters

`<1-21845>` Specify the interval in seconds. The default is 5 seconds.

Default

By default, hello interval is 5 seconds

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

This example shows how to set the `hello-interval` value for all interfaces of an LSR.

```
#configure terminal
(config)#router ldp
(config-router)#hello-interval 35

(config-router)#no hello-interval
```

hold-time

Use this command to set the global value for the hold-time after which the LSR rejects adjacencies.

An LSR maintains a record of `hello`s received from peers. `Hold-time` specifies the time an LSR maintains its record of hellos from a peer on not receiving another hello from that peer. A pair of LSRs negotiates the hold-time they use for hellos from each other. Each proposes a hold time value, and the LSR uses the lower of the two hold-time values. The hold-time value set on the interface overrides the hold-time value set by this command (see `ldp hold-time`). For optimum performance, set this value to no less than three times the value of the hello-interval specified.

Use the `no` parameter to revert to the default hold time.

Command Syntax

```
hold-time <3-65535>
no hold-time
```

Parameters

`<3-65535>` Specify the hold-time value in seconds.

Default

By default, hold time is 15 seconds

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the hold-time value for all interfaces of an LSR.

```
#configure terminal
(config)#router ldp
(config-router)#hold-time 635

(config-router)#no hold-time
```

import-bgp-routes

Use this command to import BGP routes into LDP. BGP routes are not imported into LDP by default.

Use the `no` parameter to flush out all BGP routes currently being used by LDP, and to reject any further BGP specific routing updates from OcNOS.

Command Syntax

```
import-bgp-routes
no import-bgp-routes
```

Parameters

None

Default

By default, import bgp route is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#import-bgp-routes
```

inter-area-lsp

Use this command to enable creation of inter-area LSPs.

Use the `no` form of the command to disable this configuration.

Command Syntax

```
inter-area-lsp (PREFIX_ACL|) (config-only|)
no inter-area-lsp
```

Parameters

<code>PREFIX_ACL</code>	Access-list name for Prefix Based inter-area lsp
<code>config-only</code>	Optional. When this option is used, existing LDP sessions are not torn down.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 4.0.

Example

```
#configure terminal
(config)#router ldp
(config-router)#inter-area-lsp

#configure terminal
(config)#router ldp
(config-router)#inter-area-lsp config-only

#configure terminal
(config)#router ldp
(config-router)#inter-area-lsp acl1

#configure terminal
(config)#router ldp
(config-router)#inter-area-lsp acl1 config-only
```

keepalive-interval

Use this command to set the global value for the interval after which keep-alive packets are sent out.

Each LSR must send keep-alive messages at regular intervals to its LDP peers to keep the sessions active. The keep-alive interval determines the time interval between successive keep-alive messages. Use this command to set this interval. This value is overridden by the keep-alive interval set on the interface. For optimum performance, set this value to no more than one-third the value of the specified keep-alive time-out value.

Use the `no` parameter to revert to default keep-alive interval.

Command Syntax

```
keepalive-interval <10-21845>
no keepalive-interval
```

Parameters

<10-21845> Specify the value of interval in seconds.

Default

By default, keepalive interval is 10 seconds

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the keep-alive timer for all interfaces of an LSR.

```
#configure terminal
(config)#router ldp
(config-router)#keepalive-interval 635

(config-router)#no keepalive-interval
```

keepalive-timeout

Use this command to set the global value for the time-out after which sessions are rejected.

Use this command to set the time period for which an LSR must wait for successive keep-alive messages from LDP peers. The keep-alive time-out value is overridden by the keep-alive time-out set on the interface (see `ldp keepalive-timeout`). For optimum performance, set this value to no less than three times the value of the specified keep-alive interval value.

Use the `no` parameter to revert to default keep-alive time-out.

Command Syntax

```
keepalive-timeout <30-65535>
no keepalive-timeout
```

Parameters

<30-65535> Specify the time-out value in seconds.

Default

By default, keepalive timeout is 30 seconds.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the keep-alive time-out value for all interfaces of an LSR.

```
#configure terminal
(config)#router ldp
(config-router)#keepalive-timeout 635

(config-router)#no keepalive-timeout
```

label-retention-mode

Use this command to set the retention mode to be used for all labels exchanged.

When an LSR receives a label binding for a particular FEC (Forwarding Equivalence Class) from another LSR that is not its next hop for that FEC, it might keep track of such bindings or discard them. Use the `liberal` parameter to retain all labels binding to FEC received from label distribution peers, even if the LSR is not the current next-hop. Use the `conservative` parameter to maintain only the label bindings for valid next-hops in a LSP. Liberal label retention mode allows for quicker adaptation to routing changes, whereas conservative label retention mode requires an LSR to maintain fewer labels.

Note: The retention mode value set on the interface (see [ldp label-retention-mode](#)) overrides the value set by this command.

Note: Any changes made to the retention mode for an interface (after a session is already operational) will only apply to labels received after the mode has been changed. All previously received labels will remain as they were.

Use the `no` parameter to revert to default retention mode.

Note: `label-retention-mode "liberal"` is supported with advertisement mode "DU" only.

Note: `label-retention-mode "liberal"` is not supported with advertisement mode "DOD".

Note: When the advertisement mode is set as "DU", `label-retention-mode` automatically sets to "liberal".

Note: `label-retention-mode "conservative"` is supported with advertisement mode "DOD" only.

Note: `label-retention-mode "conservative"` is not supported with advertisement mode "DU".

Note: When the advertisement mode is set as "DOD", `label-retention-mode` automatically sets to "conservative".

Command Syntax

```
label-retention-mode (conservative|liberal)
no label-retention-mode (conservative|liberal)
```

Parameters

<code>conservative</code>	Specify to delete all unused labels and FECs.
<code>liberal</code>	Specify to retain all labels, regardless of use.

Default

By default, label retention mode is liberal

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the retention mode for all interfaces of an LSR.

```
#configure terminal
(config)#router ldp
(config-router)#label-retention-mode liberal
```

Ldp advertisement-mode

Use this command to set the label advertisement mode for an interface for the current LSR to either downstream-on-demand (label is sent only when requested) or downstream-unsolicited (label is sent unrequested). Specifying downstream-on-demand and downstream-unsolicited mode affects which LSR initiates mapping requests and mapping advertisements.

This is an interface-specific command; it overrides the advertisement mode set for an LSR using the advertisement-mode command (see [advertisement-mode](#)). Use this command after the advertisement-mode command sets all the interface advertisement modes. In addition, users should use this command before starting the interface, since all affected sessions will be closed and restarted.

Use the `no` parameter to revert to the advertisement mode value set for the main LDP process.

Command Syntax

```
ldp advertisement-mode (downstream-on-demand|downstream-unsolicited)
no ldp advertisement-mode (downstream-on-demand|downstream-unsolicited)
```

Parameters

downstream-on-demand

Indicates that the sent label was requested. When a user uses this parameter, a router distributes a label to a peer only if there is a pending label request from a peer. The reaction of the downstream router to this request depends on the label advertising mode supported on the next hop. The downstream-on-demand mode is typically used with the conservative label retention mode.

downstream-unsolicited

Indicates that the label was sent unrequested. This parameter distributes labels to peers without waiting for a label request. This mode is typically used with the liberal label retention mode.

Default

By default, ldp advertisement mode is downstream unsolicited mode

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#ldp advertisement-mode downstream-on-demand
```

ldp hello-interval

Use this command to set the interval for sending multicast Hello packets via an interface.

LDP defines a mechanism for discovering adjacent Label Switching Routers (LSR) that participate in label switching (adjacencies). Whenever a new router comes up, it sends out a hello packet to a specified, multicast address announcing itself to the network. Every router directly connected to the network receives the packet. Receipt of a hello packet from another LSR creates a hello adjacency with that LSR. Use this command to specify the interval after which the hello packets will be sent.

For optimum performance, set the hello-interval value to no more than one-third the hold-time value.

Note: This command is an interface-specific command and overrides the value set for an LSR using the global hello-interval command.

Use the `no` parameter with this command to revert to the hello-interval value set for the main LDP process.

Command Syntax

```
ldp hello-interval <1-21845>
no ldp hello-interval
```

Parameters

<1-21845> Specify the interval in seconds.

Default

By default, ldp hello interval is 5 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

This example shows how to set the hello-interval for a specific interface.

```
#configure terminal
(config)#interface eth0
(config-if)#ldp hello-interval 635

(config-if)#no ldp hello-interval
```

ldp hold-time

Use this command to set the hold-time value after which the LSR rejects adjacencies.

The hold-time timer is reset every time a hello packet is received from the peer in question. For optimum performance, set this value to no less than three times the hello-interval value.

Note: This command is an interface-specific command, and overrides the value set for an LSR using the global hold-time command.

Use the `no` parameter to revert to the hold-time value set for the main LDP process.

Command Syntax

```
ldp hold-time <3-65535>
no ldp hold-time
```

Parameters

`<3-65535>` Specify the hold-time value in seconds.

Default

By default, ldp hold time is 15 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the hold-time for a specific interface:

```
#configure terminal
(config)#interface eth0
(config-if)#ldp hold-time 635

(config-if)#no ldp hold-time
```

ldp keepalive-interval

Use this command to set the interval for sending keep-alive messages to the peer in order to maintain a session.

Each LSR must send keep-alive messages at regular intervals to its LDP peers to keep the sessions active. The keep-alive interval determines the time-interval between successive keep-alive messages. This command sets this interval.

Note: This command is an interface-specific command, and overrides the value set for an LSR using the global `keepalive-interval` command.

Use the `no` parameter to revert to the keep-alive interval set for the main LDP process.

Command Syntax

```
ldp keepalive-interval <1-21845>
no ldp keepalive-interval
```

Parameters

`<1-21845>` Specify the interval in seconds.

Default

By default, ldp keepalive interval is 10 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

This example shows how to set the hello-interval for a specific interface:

```
#configure terminal
(config)#interface eth0
(config-if)#ldp keepalive-interval 635

(config-if)#no ldp keepalive-interval
```

ldp keepalive-timeout

Use this command to set the keep-alive time-out value for rejecting a session with a peer.

Use this command to set the time period for which an LSR must wait for successive keep-alive messages from LDP peers. The keep-alive timer is reset every time a keep-alive packet is received from the peer in question. For optimum performance, set this value to no more than three times the keep-alive interval value.

Note: This command is an interface-specific command and overrides the value set for an LSR using the global `keepalive-timeout` command.

Use the `no` parameter to revert to the keep-alive time-out set for the main LDP process.

Command Syntax

```
ldp keepalive-timeout <3-65535>
no ldp keepalive-timeout
```

Parameters

`<3-65535>` Specify the value in seconds.

Default

By default, ldp keepalive timeout is 30 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the keep-alive time-out timer for a specific interface:

```
#configure terminal
(config)#interface eth0
(config-if)#ldp keepalive-timeout 635

(config-if)#no ldp keepalive-timeout
```

ldp label-retention-mode

Use this command to set the retention mode to be used for all labels exchanged via the given interface.

When an LSR receives a label binding for a particular FEC (Forwarding Equivalence Class) from another LSR that is not its next hop for that FEC, it might keep track of such bindings or discard them. Use the `liberal` parameter to retain all labels binding to FEC received from label distribution peers, even if the LSR is not the current next-hop. Use the `conservative` parameter to maintain only the label bindings for valid next-hops in a LSP. Liberal label retention mode allows for quicker adaptation to routing changes, whereas conservative label retention mode requires an LSR to maintain fewer labels.

Note: The retention mode value set on the interface (see [label-retention-mode](#)) overrides the value set by this command. This command is an interface-specific command, and overrides the setting for an LSR using the global `label-retention-mode` command.

Use the `no` parameter to revert to the retention mode set for the main LDP process.

Command Syntax

```
ldp label-retention-mode (conservative|liberal)
no ldp label-retention-mode (conservative|liberal)
```

Parameters

<code>conservative</code>	Specify to delete all unused labels and FECs.
<code>liberal</code>	Specify to retain all labels, regardless of use.

Default

By default, ldp label retention mode is liberal

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the label retention mode for a specific interface:

```
#configure terminal
(config)#interface eth0
(config-if)#ldp label-retention-mode liberal
```

Ldp multicast-hellos

Use this command to enable multicast hello exchange on a specified interface.

Use the `no` parameter to disable multicast hello exchange. R

Command Syntax

```
ldp multicast-hellos
no ldp multicast-hellos
```

Parameters

None

Default

By default, ldp multicast hello is enabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#ldp multicast-hellos
```

ldp-optimization

This command helps optimize the resetting of an LDP session by enabling the following two scalability features for LDP:

- Resets the session keepalive timer on receipt of a hello message
- Resets the hold timer on receipt of any LDP control message

Use the `no` parameter to disable the two previously listed scalability features.

Command Syntax

```
ldp-optimization
no ldp-optimization
```

Parameters

None

Default

By default, ldp optimization is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#ldp-optimization
```

loop-detection

Use this command to enable loop detection on the current LSR. This command detects looping LSPs, and prevent Label Request messages from looping because of non-merge capable LSRs. This loop detection mechanism is useful for networks of non time-to-live (non TTL) decrementing devices that can not allocate resources among traffic flows.

There are two methods supported for the loop detection mechanism: A Hop Count detection system, that is always enabled; and the Path Vector detection system, that can be toggled:

- Hop Count - During the setup of an LSP, the LSP passes a hop count with the LSP setup messages. This hop count is incremented by each node router participating in LSP establishment. If the hop count exceeds the maximum configured value, the LSP setup process is stopped, and a notification message is passed back to the message originator.
- Path Vector - A path vector contains a list of LSR identifiers. This is passed as a part of LSP setup messages. Each LSR participating in the LSP establishment adds its own LSR identifier to the path vector. If an LSR finds its own identifier in the path vector, it drops the message, and sends a message back to the originator.

The use of these messages ensures that a loop is detected while establishing a label switched path and before any data is passed over that LSP.

Use the `no` parameter to disable loop detection.

Command Syntax

```
loop-detection
no loop-detection
```

Parameters

None

Default

By default, loop detection is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#loop-detection
```

loop-detection-hop-count

Use this command to set the loop detection hop count, which determines the maximum hop-count value.

This command sets the maximum hop count value, which specifies the permitted maximum permitted hop-count. An LSR that detects a maximum hop count behaves as if the containing message has traversed a loop. The use of this command ensures that a loop is detected while establishing a label switched path before any data is passed via LSP.

Use the `no` parameter to revert to the default loop detection count

Command Syntax

```
loop-detection-hop-count <1-255>
```

Parameters

<1-255>	Indicates the loop detection hop count.
---------	---

Default

By default, loop detection hop is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#loop-detection-hop-count 128
```

loop-detection-path-vec-count

Use this command to set the loop detection vec (vector) count, which determines the maximum supported path vectors.

This command sets the maximum supported path vectors for loop detection, which specifies the permitted path vector length. An LSR that detects a path vector has reached the maximum length behaves as if the containing message has traversed a loop. This command ensures that a loop is detected while establishing a label switched path before any data is passed over that LSP.

Use the `no` parameter to revert to the default loop detection count

Command Syntax

```
loop-detection-path-vec-count <1-255>
```

Parameters

<1-255>	Indicates the loop detection hop count.
---------	---

Default

By default, loop detection path vec count is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#loop-detection-path-vec-count 123
```

mpls ldp-igp sync isis

Use this command to enable LDP ISIS synchronization and to set the holddown timer for synchronization.

Use the `no` parameter to disable the LDP ISIS synchronization.

Note: Holddown timer value should be higher than LDP IGP sync timer.

Command Syntax

```
mpls ldp-igp sync isis (level-1|level-2|level-1-2) (holddown-timer <1-2147483>| )
```

Parameters

`level-1|level-2|level-1-2`

The ISIS level.

`holddown-timer` How long IGP should wait for LDP to converge in seconds.

Default

None

Command Mode

Interface configuration mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
#int eth 1
#mpls ldp-igp sync isis level-1-2 holddown-timer 500
```

mpls ldp-igp sync ospf

Use this command to enable LDP-OSPF synchronization. This command also provides option to configure the hold-down timer for which OSPF will wait for LDP to converge and advertises Max cost. When the configured time expires, OSPF starts advertising the actual cost in the Router-LSA.

Note: Holddown timer value should be higher than LDP IGP sync timer.

Command Syntax

```
mpls ldp-igp sync ospf (holddown-timer <1-2147483>|)
```

Parameters

holddown-timer	Set holddown timer for the OSPF Sync
<1-2147483>	Hold down timer in seconds

Default

OSPF waits infinite when no hold-down timer is configured.

Command Mode

Interface configuration mode

Applicability

This command was introduced before OcNOS version 4.0.

Example

Enabling OSPF-LDP sync in interface eth3

```
#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
(config)#int eth3
(config-if)#mpls ldp-igp sync ospf
(config-if)#end
```

Enabling OSPF-LDP sync with holdown-timer enabled

```
#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
(config)#int eth3
(config-if)#mpls ldp-igp sync ospf holddown-timer 200
(config-if)#no mpls ldp-igp sync ospf
(config-if)#end
#
```

mpls ldp-igp sync-delay

Use this command to set the time delay for LDP-IGP synchronization.

Use the `no` parameter to disable the time delay.

Command Syntax

```
mpls ldp-igp sync-delay <5-60>
no mpls ldp-igp sync-delay
```

Parameters

<code>sync-delay</code>	Time delay for LDP to converge in seconds.
<code><5-60></code>	Time delay for notification of LDP convergence to IGP, in seconds

Default

If not configured the delay will be 0 seconds.

Command Mode

Interface configuration mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config-if)# interface eth0
(config-if)# mpls ldp-igp sync-delay 15
(config-if)# no mpls ldp-igp sync-delay
```

multicast-hellos

Use this command to enable multicast hello exchange on all interfaces enabled for LDP. This is used for auto-discovery of LDP peers on directly connected networks. This option is enabled by default.

Use the `no` parameter with this command to disable multicast hello exchange.

Command Syntax

```
multicast-hellos
no multicast-hellos
```

Parameters

None

Default

By default, multicast hello is enabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#multicast-hellos
```

neighbor

Use this command to configure neighbors of LDP.

Use the `no` parameter with this command to unconfigure the LDP neighbor.

Command Syntax

```
neighbor A.B.C.D auth AUTH-TYPE password (0|7) WORD
no neighbor A.B.C.D auth AUTH-TYPE password
```

Parameters

A.B.C.D	Neighbor address
auth AUTH-TYPE	Authentication Type md5
password	Set password to the neighbor
(0 7)	Password Type
WORD	Password

Default

By default, neighbor is disabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#neighbor 1.1.1.1 auth md5 password 0 myPass

(config-router)#no neighbor 1.1.1.1 auth md5 password
```

propagate-release

Use this command to propagate the release of labels to downstream routers.

Use the `no` parameter to prevent the propagate-release of labels.

Command Syntax

```
propagate-release
no propagate-release
```

Parameters

None

Default

By default, propagate release is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#propagate-release
```

pw-status-tlv

Use this command to enable the use of the PW Status TLV to signal the pseudowire status.

Use the `no` option with this command to disable the use of the PW Status TLV to signal the pseudowire status.

Command Syntax

```
pw-status-tlv
no pw-status-tlv
```

Parameters

None

Default

By default, pw status tlv is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#pw-status-tlv
```

request-labels-for

Use this command to request labels for the prefixes in the given IP prefix list. LDP request labels for the prefixes only if the valid and exact route is present for that prefix.

Use the no form of this command to disable multicast hello exchange.

Command Syntax

```
request-labels-for prefix-list-ipv4 NAME
no request-labels-for prefix-list-ipv4
```

Parameters

NAME	IPv4 prefix list name
------	-----------------------

Command Mode

LDP router mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#request-labels-for prefix-list-ipv4 myPrefixList
```

request-retry

Use this command to enable the retry of requests once a request for a label has been rejected for a valid reason. This command enables the LSR to send a maximum of five label requests if a label request is rejected by an LDP peer.

Use the `no` parameter to disable the retry of requests.

Command Syntax

```
request-retry
no request-retry
```

Parameters

None

Default

By default, request retry is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#request-retry
```

request-retry-timeout

Use this command to set the interval between retries. Before this time is over, a request is re-sent to a peer. This command changes the interval between request messages that are resent to a peer to account for routing changes.

Use the `no` parameter to revert to the default request-retry time-out set.

Command Syntax

```
request-retry-timeout <1-65535>
no request-retry-timeout
```

Parameter

<1-65535> Specify the interval between retries in seconds.

Default

By default, timeout is 5 seconds.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#request-retry-timeout 512

(config-router)#no request-retry-timeout
```

restart ldp graceful

Use this command to restart ldp gracefully.

Command Syntax

```
restart ldp graceful
```

Parameter

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#restart ldp graceful
```

```
% Warning : LDP process will stop and needs to restart manually,  
You may loose LDP configuration, if not saved  
Proceed for graceful restart? (y/n):y
```

rlfa-ilm-optimization

Use this command to enable ILM optimization for rLFA. When ILM optimization is enabled, ILM delete and POP operations are delayed. ILM delete/POP configuration is delayed to make sure rLFA backup path is not removed immediately upon IGP network convergence.

Use the `no` parameter with this command to revert this configuration.

Command Syntax

```
rlfa-ilm-optimization
no rlfa-ilm-optimization
```

Parameter

None

Default

By default, ILM optimization is disabled.

Command Mode

Router(LDP) Config mode.

Applicability

This command was introduced before OcNOS version 6.2.0.

Example

```
(config)#router ldp
(config-router)# rlfa-ilm-optimization
```

router ldp

This command is used to enter the LDP specific command-line mode in which global attributes for the LDP process can be set. Without this command, the LSR does not perform any LDP operations, such as sending `hello` packets.

Use the `no` parameter with this command to disable this configuration.

Command Syntax

```
router ldp
no router ldp
```

Parameters

None

Default

By default, router ldp is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following example shows the change in the prompt after using this `router ldp` command to enter router mode.

```
#configure router
(config)#router ldp
(config-router)#
```

router-id

Use this command to set the router-id to the supplied IP address; the router uses this address to generate the LDP-ID.

OcNOS has three methods to choose the router-id of LDP. The first priority router-id is the configured router-id in router mode (local configured router-id). The second priority router-id is the configured router-id in configure mode (global configured router-id). The lowest priority router-id is chosen by OcNOS among interfaces (global computed router-id).

Use the `no` parameter with this command to revert to using the first IP address configured on the box as the router-id for LDP-ID generation purposes.

Command Syntax

```
router-id A.B.C.D
no router-id A.B.C.D
no router-id
```

Parameter

A.B.C.D	Indicates the LDP router ID value.
---------	------------------------------------

Default

By default, router id is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure router
(config)#router ldp
(config-router)#router-id 123.123.123.8
```

snmp restart ldp

Use this command to restart SNMP in Label Distribution Protocol (LDP)

Command Syntax

```
snmp restart ldp
```

Parameters

None

Default

By default, snmp restart ldp is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#snmp restart ldp
```

targeted-peer ipv4

Use this command to enter a targeted IPv4 LDP peer mode.

A targeted session is an LDP session between non-directly connected LSRs. Set this command to send a targeted hello messages to specific IP addresses. This command is specific to a targeted IPv4 LDP peer.

Command Syntax

```
targeted-peer ipv4 A.B.C.D
no targeted-peer ipv4 A.B.C.D
```

Parameter

A.B.C.D	Specifies the IPv4 address of the targeted peer.
tunneling	Enables tunneling functionality for the targeted peer.

Default

Disabled

Command Mode

Configure mode and Targeted-peer

Applicability

This command was introduced before OcNOS version 1.3. Added new parameter `tunneling` for OcNOS version 6.5.3.

Examples

```
#configure terminal
ocnos(config)#router ldp
ocnos(config-router)#targeted-peer ipv4 10.10.10.10
ocnos(config-router-targeted-peer)#
```

targeted-peer hello-interval

Use this command to modify hello interval for targeted peers.

Use the `no` parameter with this command to unset hello interval for targeted peers.

Command Syntax

```
hello-interval <1-21845>
no hello-interval
```

Parameter

<1-21845>	Interval for sending periodic hello message to peers.
-----------	---

Default

15

Command Mode

Targeted-peer mode

Applicability

This command was introduced before OcNOS version 6.5.3.

Example

```
ocnos(config)#router ldp
ocnos(config-router)#targeted-peer ipv4 1.1.1.1
ocnos(config-router-targeted-peer)# hello-interval 10
```

targeted-peer hold-time

Use this command to set the hold time for a targeted LDP peer.

Use the `no` parameter with this command to unset hold time for a targeted LDP peer.

Command Syntax

```
hold-time <3-65535>
no hold-time
```

Parameter

`<3-65535>` Hold time in seconds as time-out value that the router waits before rejecting an adjacency.

Default

45

Command Mode

Targeted-peer mode

Applicability

This command was introduced before OcNOS version 6.5.3.

Example

```
ocnos(config)#router ldp
ocnos(config-router)#targeted-peer ipv4 1.1.1.1
ocnos(config-router-targeted-peer)# hold-time 4
```

targeted-peer tunneling

Use this command to enable the TLDP peer to tunnel LDP FECs.

Use the `no` parameter with this command to disable the TLDP peer to tunnel LDP FECs.

Command Syntax

```
tunneling
no tunneling
```

Parameter

None

Default

Disable

Command Mode

Targeted-peer mode

Applicability

This command was introduced before OcNOS version 6.5.4.

Example

```
Enter configuration commands, one per line.  End with CNTL/Z.
ocnos(config)#router ldp
ocnos(config-router)# targeted-peer ipv4 2.2.2.2
ocnos(config-router-targeted-peer)#tunneling
ocnos(config-router-targeted-peer)#commit
```

targeted-peer-hello-interval

Use this command to set the interval for sending unicast `hello` packets to targeted peers.

Use the `no` parameter with this command to revert to the default targeted-peer hello-interval value.

Command Syntax

```
targeted-peer-hello-interval <1-21845>
no targeted-peer-hello-interval
```

Parameter

`<1-21845>` Specify the interval in seconds.

Default

By default, targeted peer hello interval is 15 seconds.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#targeted-peer-hello-interval 1
```

targeted-peer-hold-time

Use this command to set the time-out value that is the time that the router waits before rejecting an adjacency with targeted peers.

Use the `no` parameter to revert to the default targeted-peer hold-time value.

Command Syntax

```
targeted-peer-hold-time <3-65535>
no targeted-peer-hold-time
```

Parameter

<3-65535> Specify the interval in seconds.

Default

By default, hold time is 45 seconds.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#targeted-peer-hold-time 555

(config-router)#no targeted-peer-hold-time
```

transport-address ipv4

Use this command to configure the IPv4 transport address for a label space.

The transport address is the address used for the TCP session over which LDP is running. Use this command to manually configure the transport address. Transport addresses may either be bound to a loopback interface, or to a physical interface that is bound to the label space in question. A transport address can also be manually configured using the CLI with the loopback address as the transport address.

Note: The CLI accepts only the loopback address to be configured as the transport address.

Use the `no` parameter to stop using the transport address as the IPv4 transport address. If the label space is not specified for either form of this command, a label space of zero is assumed.

Command Syntax

```
transport-address ipv4 A.B.C.D
transport-address ipv4 A.B.C.D 0
no transport-address ipv4 A.B.C.D
no transport-address ipv4 A.B.C.D 0
```

Parameters

A.B.C.D	Specify the IPv4 address to be used as the transport address. Only addresses bound to a loopback interface are valid for manual transport address configuration.
0	Platform-wide label space for which a transport address is being configured (Platformwide labels are used for all interfaces that can share the same labels)

Default

Transport addresses are chosen for label spaces. By default, the loopback address is selected as the transport address. If a loopback address is not configured, the label space value is examined. The IP address of the interface is bound to the same label space is chosen as the transport address.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure router
(config)#router ldp
(config-router)#transport-address ipv4 10.10.0.5 0
```

CHAPTER 2 LDP Show Commands

This chapter provides an alphabetized reference for each of the LDP commands. It includes the following commands:

- `show debugging ldp`
- `show ldp`
- `show ldp adjacency`
- `show ldp advertise-labels`
- `show ldp downstream`
- `show ldp fec`
- `show ldp igp sync`
- `show ldp inter-area-fecs`
- `show ldp inter-area-fecs prefix`
- `show ldp lsp`
- `show ldp label-pool`
- `show ldp mpls-l2-circuit`
- `show ldp rfa-routes`
- `show ldp routes`
- `show ldp routes count`
- `show ldp rfa-routes count`
- `show ldp session`
- `show ldp statistics`
- `show ldp statistics advertise-labels`
- `show ldp targeted-peers`
- `show ldp tunneling`
- `show ldp tunneling-fec`
- `show ldp tunneling-tunnels`
- `show ldp vpls`
- `show ldp vpls`
- `show mpls ldp discovery`
- `show mpls ldp neighbor`
- `show mpls ldp parameter`

show debugging ldp

Use this command to display the status of the debugging of the LDP system.

Command Syntax

```
show debugging ldp
```

Parameter

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output from the `show debugging ldp` command.

```
#show debugging ldp
LDP debugging status:
  LDP event debugging is on
  LDP packet debugging is on
  LDP finite state machine debugging is on
  LDP pdu hexdump debugging is on
  LDP downstream state machine debugging is on
  LDP upstream state machine debugging is on
  LDP trunk state machine debugging is on
  LDP QoS debugging is on
  LDP CSPF debugging is on
  LDP VC USM debugging is on
  LDP VC DSM debugging is on
  LDP NSM debugging is on
  LDP Advertise-labels debugging is on
#
```

Table 2-1 explains the show command output fields.

Table 2-1: show debugging ldp output fields details

Field	Description
LDP debugging status	Status of the LDP debugging protocol.

show ldp

Use this command to display basic LDP attributes defined for the current LSR.

Command Syntax

```
show ldp
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following is a sample output from the `show ldp` command displaying basic LDP attributes.

```
#show ldp
Router ID : 20.1.1.1
LDP Version : 1
Global Merge Capability : Merge Capable
Label Advertisement Mode : Downstream Unsolicited
Label Retention Mode : Liberal
Label Control Mode : Independent
Instance Loop Detection : On
Instance Hop Count Limit : 255
Instance Path Vec Count : 255
Request Retry : Off
Propagate Release : Disabled
Graceful Restart : Disabled
Hello Interval : 5
Targeted Hello Interval : 15
Hold time : 15
Targeted Hold time : 45
Keepalive Interval : 10
Keepalive Timeout : 30
Request retry Timeout : 5
Transport Address data :
Labelspace 0 : 20.1.1.1 (in use)
Import BGP routes : No
#
```

[Table 2-2](#) explains the show command output fields.

Table 2-2: show ldp output fields details:

Field	Description
Router ID	Router identifier in IP address format for this system.
LDP Version	Details of Link Layer Discovery Protocol (LLDP) version.
Global Merge Capability	Used to override the default merge capability setting of all the interfaces for the current LSR.
Label Advertisement Mode	Used to set the label advertisement mode for an interface for the current LSR to either downstream-on-demand (label is sent only when requested) or downstream-unsolicited (label is sent unrequested).
Label Retention Mode	Used for all labels exchanged via the given interface.
Label Control Mode	LSR generates a local label for a FEC which the router learned from routing table independently from other LSRs.
Loop Detection	Used to enable loop detection on the current LSR.
Loop Detection Count	Indicates the loop detection hop count.
Request Retry	Enables the LSR to send a maximum of five label requests.
Propagate Release	Used to propagate the release of labels to downstream routers.
Hello Interval	Sets the interval for sending unicast hello packets to peers.
Targeted Hello Interval	Sets the interval for sending unicast hello packets to targeted peers.
Hold time	Sets the time-out value to peers.
Targeted Hold time	Sets the time-out value that is the time that the router waits before rejecting an adjacency with targeted peers.
Keepalive Interval	Used to set the interval for sending keep-alive messages to the peer in order to maintain a session.
Keepalive Timeout	Time-out value for rejecting a session with a peer.
Request retry Timeout	Used to set the interval between retries.
Targeted Hello Receipt	Status of the hello receipt.
Transport Address	The transport address is the address used for the TCP session over which LDP is running.
Transport Interface	Interface is used for the TCP session over which LDP is running.
Import BGP routes	Used to import BGP routes into LDP.

show ldp adjacency

Use this command to display all the adjacencies for the current LSR.

Command Syntax

```
show ldp adjacency
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output from the `show ldp adjacency` command displaying all the adjacencies for this LSR.

```
#show ldp adjacency
Remote-Address  Local-Address  Mode           Intf-Name  Holdtime  LDP-Identifier
11.11.11.11     12.0.1.20     Targeted      ge11       45        11.11.11.11:0
33.33.33.33     11.0.1.20     Targeted      ge9        45        33.33.33.33:0
44.44.44.44     20.0.1.20     Targeted      xe14       45        44.44.44.44:0
11.0.1.10       11.0.1.20     Interface     ge9        15        33.33.33.33:0
12.0.1.10       12.0.1.20     Interface     ge11       15        11.11.11.11:0
20.0.1.10       20.0.1.20     Interface     xe14       15        44.44.44.44:0
```

[Table 2-3](#) explains the show command output fields.

Table 2-3: show ldp adjacency output fields details

Field	Description
Remote Address	IP address of the interface.
Local Address	Local address of the LDP adjacency.
Interface Name	Name of the interface.
Hold time	Sets the time-out value to peers.
LDP ID	LDP identifier for this protocol.

show ldp advertise-labels

Use this command to display the IP access list of LDP advertise-labels.

Command Syntax

```
show ldp advertise-labels
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output from the `show ldp advertise-labels` command.

```
#show ldp advertise-labels
Advertisement spec:
  Prefix list = pfx1; Peer plist = pfx1
  Prevent the distribution of any assigned labels
```

[Table 2-4](#) explains the show command output fields.

Table 2-4: show ldp advertise-labels output fields details

Field	Description
Advertisement spec	Details of the advertisement spec.
Prefix list	The label is advertised to all peers permitted by the peer plist.
Peer plist	The prefix list permits the prefix and there is a peer plist.

show ldp downstream

Use this command to display the status of all downstream sessions and the label information exchanged.

Command Syntax

```
show ldp downstream (session A.B.C.D|prefix A.B.C.D/M|)
```

Parameter

prefix	Ldp upstream for prefix
session	LDP Session

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3 and was updated in OcNOS version 6.5.4.

Example

The following is an output from the `show ldp downstream` command showing the status of all downstream sessions.

When LDP LFA FRR in not enabled:

```
#show ldp downstream
Session peer 44.1.1.1:
  FEC           Nexthop Addr   State      Label      Req.ID     Attr
  192.168.254.0/24 connected Established impl-null  0
  33.1.1.1/32   10.0.4.1   Established 24323      0
  10.0.4.0/31   connected Established impl-null  0
  10.0.2.0/31   connected Established 24322      0
  44.1.1.1/32   10.0.4.1   Established impl-null  0
  10.0.3.0/31   10.0.4.1   Established impl-null  0
Session peer 22.1.1.1:
  FEC           Nexthop Addr   State      Label      Req.ID     Attr
  192.168.254.0/24 connected Established impl-null  0
  10.0.3.0/31   connected Established 24323      0
  10.0.1.0/31   connected Established impl-null  0
  33.1.1.1/32   10.0.1.1   Established 24324      0
  22.1.1.1/32   10.0.1.1   Established impl-null  0
  10.0.2.0/31   10.0.1.1   Established impl-null  0
```

When LDP LFA FRR in enabled:

```
#show ldp downstream
Codes: P - Primary route, B - Backup route
Session peer 44.1.1.1:
```

FEC	Nexthop Addr	State	Label	Req.ID	Attr	Code
192.168.254.0/24	connected	Established	impl-null	0		
33.1.1.1/32	10.0.4.1	Established	24323	0		
P 33.1.1.1/32	10.0.4.1	Established	24323	0		
B 10.0.4.0/31	connected	Established	impl-null	0		
10.0.2.0/31	connected	Established	24322	0		
10.0.2.0/31	10.0.4.1	Established	24322	0		
B 44.1.1.1/32	10.0.4.1	Established	impl-null	0		
P 10.0.3.0/31	10.0.4.1	Established	impl-null	0		

Codes: P - Primary route, B - Backup route

Session peer 22.1.1.1:

FEC	Nexthop Addr	State	Label	Req.ID	Attr	Code
192.168.254.0/24	connected	Established	impl-null	0		
10.0.3.0/31	connected	Established	24323	0		
10.0.3.0/31	10.0.1.1	Established	24323	0		B
10.0.1.0/31	connected	Established	impl-null	0		
33.1.1.1/32	10.0.1.1	Established	24324	0		P
33.1.1.1/32	10.0.1.1	Established	24324	0		B
22.1.1.1/32	10.0.1.1	Established	impl-null	0		P
10.0.2.0/31	10.0.1.1	Established	impl-null	0		P

```
R1#show ldp downstream session 11.11.11.11
! [execution timestamp : 2025 Apr 03 10:59:25]
FEC Nexthop Addr State Label Req.ID Attr Installed Code

Codes: P - Primary route, B - Backdown route
Session peer 11.11.11.11:
11.11.11.11/32 non-nh Established 26276 0 None No -
14.14.14.14/32 non-nh Established 26241 0 None No -
[Summary] total downstreams: 3
[state] depend: 0, idle: 0, resp: 0, estab: 2, inactive: 0
[label] user-label: 2, impl-null: 0, expl-null: 0, invalid: 0
```

```
R1#show ldp downstream prefix 14.14.14.14/32
! [execution timestamp : 2025 Apr 03 10:59:34]
FEC Nexthop Addr State Label Req.ID Attr Installed Code
Codes: P - Primary route, B - Backdown route
Session peer 11.11.11.11 :
14.14.14.14/32 non-nh Established 26241 0 None No -
Session peer 14.14.14.14 :
14.14.14.14/32 60.60.60.1 Established impl-null 0 None Yes P
```


Table 2-5 explains the show command output fields.

Table 2-5: show ldp downstream output fields details

Field	Description
Session peer	Used to group and apply the configuration of general session commands to groups of neighbors that share common session configuration elements.
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
Nexthop addr	Displays the IP address of the next hop.
State	Displays the current status of the ldp.
Label	Details of the ldp downstream labels.
Req.ID	Request identifier for the protocol.
Attr	The attribute is used to sent to a customer router.
Code	Show if an entry is principal or backup.

show ldp fec

Use the following command to display all FECs (Forwarding Equivalence Classes) known to this LSR.

Command Syntax

```
show ldp fec
show ldp fec (prefix)
show mpls ldp fec
show mpls ldp fec (prefix|)
```

Parameter

prefix Display prefix FEC information.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3 and was updated in OcNOS version 5.1.

Example

When LDP LFA FRR in not enabled:

```
#show ldp fec
LSR codes      : E/N - LSR is egress/non-egress for this FEC,
                  L - LSR received a label for this FEC,
                  > - LSR will use this route for the FEC
```

FEC	Code	Session	Out Label	ELC	Nexthop Addr
10.0.1.0/31	NL	22.1.1.1	impl-null	No	connected
	E >	non-existent	none	No	connected
10.0.2.0/31	NL	44.1.1.1	24322	No	no nexthop
	NL>	22.1.1.1	impl-null	No	10.0.1.1
10.0.3.0/31	NL	22.1.1.1	24323	No	no nexthop
	NL>	44.1.1.1	impl-null	No	10.0.4.1
10.0.4.0/31	NL	44.1.1.1	impl-null	No	connected
	E >	non-existent	none	No	connected
11.1.1.1/32	E >	non-existent	none	No	connected
22.1.1.1/32	NL>	22.1.1.1	impl-null	No	10.0.1.1
33.1.1.1/32	NL>	44.1.1.1	24323	No	10.0.4.1
	NL>	22.1.1.1	24324	No	10.0.1.1
44.1.1.1/32	NL>	44.1.1.1	impl-null	No	10.0.4.1
192.168.254.0/24	NL	22.1.1.1	impl-null	No	connected
	NL	44.1.1.1	impl-null	No	connected
	E >	non-existent	none	No	connected

When LDP LFA FRR in enabled:

```
#show ldp fec
LSR codes      : E/N - LSR is egress/non-egress for this FEC,
                  L - LSR received a label for this FEC,
```

P - Primary route, B - LFA Backup route,
R - Remote LFA Backup route,
> - LSR will use this route for the FEC

FEC	Code	Session	Out Label	ELC	Nexthop Addr
10.0.1.0/31	NL	22.1.1.1	impl-null	No	connected
	E >	non-existent	none	No	connected
10.0.2.0/31	NLB>	44.1.1.1	24322	No	10.0.4.1
	NLP>	22.1.1.1	impl-null	No	10.0.1.1
10.0.3.0/31	NLB>	22.1.1.1	24323	No	10.0.1.1
	NLP>	44.1.1.1	impl-null	No	10.0.4.1
10.0.4.0/31	NL	44.1.1.1	impl-null	No	connected
	E >	non-existent	none	No	connected
11.1.1.1/32	E >	non-existent	none	No	connected
22.1.1.1/32	NLP>	22.1.1.1	impl-null	No	10.0.1.1
33.1.1.1/32	NLP>	44.1.1.1	24323	No	10.0.4.1
	NLB>	44.1.1.1	24323	No	10.0.4.1
	NLP>	22.1.1.1	24324	No	10.0.1.1
	NLB>	22.1.1.1	24324	No	10.0.1.1
44.1.1.1/32	NLP>	44.1.1.1	impl-null	No	10.0.4.1
1.1.1.1/32	NL	1.1.1.1	impl-null	No	no nexthop
	NLP>	3.3.3.3	24320	No	30.1.1.1
	NLB>	3.3.3.3	24320	No	30.1.1.1
	NLP>	2.2.2.2	24320	No	20.1.1.1
	NLB>	2.2.2.2	24320	No	20.1.1.1
2.2.2.2/32	NLR>	1.1.1.1	24324	No	1.1.1.1
			(via 30.1.1.1, label 24320)		
	NLP>	2.2.2.2	impl-null	No	20.1.1.1
192.168.254.0/24	NL	22.1.1.1	impl-null	No	connected
	NL	44.1.1.1	impl-null	No	connected
	E >	non-existent	none	No	connected

Table 2-6 shows the codes at the end of each route entry that indicate where the route originated.

Table 2-6: Origin Codes

Origin Code	Description	Comments
E/N	Egress/Non-egress	LSR is egress/non-egress for this FEC.
L	LSR	LSR received a label for this FEC.
>		LSR will use this route for the FEC.
P	Primary route	When LDP LFA FRR is enabled
B	LFA Backup route	When LDP LFA FRR is enabled
R	Remote LFA Backup route	When LDP LFA FRR is enabled

Table 2-7 explains the show command output fields.

Table 2-7: show ldp fec output fields details

Field	Description
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
Session	Reports the current session state.
Out Label	Label received from downstream neighbor for route.
ELC	Displays if route has ELC
Nexthop addr	Displays the IP address of the next hop.

show ldp igp sync

Use the following command to display the LDP synchronization status.

Command Syntax

```
show ldp igp sync
show mpls ldp igp sync
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show ldp igp sync
eth1
LDP configured; LDP-IGP Synchronization enabled.
Sync status: sync achieved
Delay timer: Not Configured , Not Running
```

show ldp inter-area-fecs

Use this command to show all FECs using the LPM-based mapping procedure.

Command Syntax

```
show ldp inter-area-fecs
show ldp inter-area-fecs (ipv4|ipv6|) (count)
```

Parameter

ipv4	IPv4 FECs
ipv6	IPv6 FECs
count	Count of FECs

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 4.0 and the command was updated in OcNOS version 4.1.

Example

```
#show ldp inter-area-fecs
LSR codes : E/N - LSR is egress/non-egress for this FEC,
L - LSR received a label for this FEC,
> - LSR will use this route for the FEC
Code FEC Session Out Label Nexthop Addr
Matching RIB prefix - 1.1.1.0
NL> 1.1.1.1/32 33.33.33.33 52485 11.11.11.1
NL> 1.1.1.2/32 33.33.33.33 52486 11.11.11.1

#show ldp inter-area-fecs count
-----
Num. IPv4 FEC(s) : 9
-----
-----
Num. IPv6 FEC(s) : 0
-----
-----
Total Num. FEC(s): 9
-----

#show ldp inter-area-fecs ipv4 count
-----
Num. IPv4 FEC(s) : 9
-----

#show ldp inter-area-fecs ipv6 count
-----
```

Num. IPv6 FEC(s) : 0

show ldp inter-area-fecs prefix

Use this command to show all LDP inter-area FECs by prefix.

Use parameter count to show FEC count for each prefix.

Command Syntax

```
show ldp inter-area-fecs prefix (A.B.C.D/M|X:X::X:X/M) count
```

Parameter

A.B.C.D/M	IP prefix <network>/<length>, e.g., 35.0.0.0/8
X:X::X:X/M	IPv6 prefix <network>/<length>, e.g., 3ffe::/16
count	Count of FECs

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.1.

Examples

```
#show ldp inter-area-fecs prefix 4.4.4.0/30
```

```
LSR codes      : E/N - LSR is egress/non-egress for this FEC,
                  L - LSR received a label for this FEC,
                  > - LSR will use this route for the FEC
```

FEC	Code	Session	Out Label	ELC	Nexthop Addr
Matching RIB prefix - 4.4.4.0/30					
4.4.4.1/32	NL>	1.1.1.1	24970	No	12.1.1.1
	NL>	3.3.3.3	24329	No	23.1.1.2
4.4.4.2/32	NL>	1.1.1.1	24971	No	12.1.1.1
	NL>	3.3.3.3	24330	No	23.1.1.2
4.4.4.3/32	NL>	1.1.1.1	24972	No	12.1.1.1
	NL>	3.3.3.3	24331	No	23.1.1.2

```
#show ldp inter-area-fecs prefix 4.4.4.0/30 count
```

```
Matching RIB prefix - 4.4.4.0/30
```

```
-----
Num. IPv4 FEC(s) : 3
-----
```

```
#show ldp inter-area-fecs prefix 3ffe::/16
```

```
LSR codes      : E/N - LSR is egress/non-egress for this FEC,
                  L - LSR received a label for this FEC,
                  > - LSR will use this route for the FEC
```

FEC	Code	Session	Out Label	ELC	Nexthop Addr
-----	------	---------	-----------	-----	--------------

```
#show ldp inter-area-fecs prefix 3ffe::/16 count
```

show ldp interface

Table 2-8: show ldp fec output fields details

Field	Description
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
Session	Reports the current session state.
Out Label	Label received from downstream neighbor for route.
Nexthop addr	Displays the IP address of the next hop.

Use this command to display the list of all interfaces on the current LSR, and to indicate whether a given interface is label-switching or not.

Command Syntax

```
show ldp interface
show ldp interface IFNAME
```

Parameter

IFNAME Displays the name of the interface.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following output displays a list of all interfaces on the LSR.

```
#show ldp interface
InterfaceLDP IdentifierLabel-switchingMerge Capability
eth010.10.0.11:0DisabledN/A
lo10.10.0.11:0DisabledN/A
eth110.10.0.11:0Enabled Merge capable
eth210.10.0.11:0Enabled Merge capable
vmnet1 10.10.0.11:0Disabled N/A
```

The following is a sample output from the `show ldp interface IFNAME` command displaying information about the specified interface `eth1`.

```
#show ldp interface eth1
Status : Enabled
Primary IP Address : 192.168.3.4
Interface Type : Ethernet
Label Merge Capability : Merge Capable
Hello Interval : 5
Targeted Hello Interval : 15
Hold Time : 15
Targeted Hold Time : 45
```

```

Keepalive Interval      : 10
Keepalive Timeout      : 30
Advertisement Mode      : Downstream On Demand
Label Retention Mode    : Liberal
Administrative Groups   : myGroup

```

Table 2-9 explains the show command output fields.

Table 2-9: show ldp interface output fields details

Field	Description
Interface	Name of the interface.
LDP Identifier	LDP identifier for this protocol.
Label-switching	Status of the label-switching on interface..
Merge Capability	Used to override the default merge capability setting of all the interfaces.
Status	Status of the ldp interface.
Primary IP Address	Address of the primary Internet protocol in the interface.
Interface Type	Type of interface.
Label Merge Capability	Used to override the default merge capability setting of all the interfaces for the label.
Hello Interval	Sets the interval for sending unicast hello packets to peers.
Targeted Hello Interval	Sets the interval for sending unicast hello packets to targeted peers.
Hold time	Sets the time-out value to peers.
Targeted Hold time	Sets the time-out value that is the time that the router waits before rejecting an adjacency with targeted peers.
Keepalive Interval	Used to set the interval for sending keep-alive messages to the peer in order to maintain a session.
Keepalive Timeout	Time-out value for rejecting a session with a peer.
Label Advertisement Mode	Used to set the label advertisement mode for an interface for the current LSR to either downstream-on-demand (label is sent only when requested) or downstream-unsolicited (label is sent unrequested).
Label Retention Mode	Used for all labels exchanged via the given interface.
Administrative Groups	Administrative group to be used for links.

show ldp label-pool

Use this command to display the label management in LDP protocol.

Command Syntax

```
show ldp label-pool (block-id <0-1638>|)
```

Parameters

block-id Block identifier of a block that is allocated to the protocol

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 6.5.4.

Example

```
show ldp label-pool
Module: LDP, Label range: 16-1048575, Current block: 40
+-----+-----+-----+-----+-----+-----+-----+
---+
block_id label_min label_max usable_labels free_labels first_free_label
+-----+-----+-----+-----+-----+-----+-----+
---+
40 25600 26239 640 628 25612
Total - blocks: 1, used-labels: 12, free-labels: 628
Module: LDP-VC, Label range: 16-1048575, Current block: 79
+-----+-----+-----+-----+-----+-----+-----+
---+
block_id label_min label_max usable_labels free_labels first_free_label
+-----+-----+-----+-----+-----+-----+-----+
---+
41 26240 26879 640 0 0
79 50560 51199 640 456 50744
Total - blocks: 2, used-labels: 824, free-labels: 456
```

show ldp lsp

Use this command to display LDP LSP and, optionally, advertise-label information.

Command Syntax

```
show ldp lsp
show ldp lsp prefix detail
show ldp lsp (prefix|detail)
```

Parameter

prefix	Displays advertise-label information in addition to LDP LSP information.
detail	Displays advertise-label information in addition to LDP LSP information.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3. and was updated in OcNOS version 5.1.

Example

The following is a sample output from the `show ldp lsp prefix detail` command displaying LDP LSP prefix information with advertise-label information.

When LDP LFA FRR in not enabled:

```
#show ldp lsp
DOWNSTREAM LSP :
  FEC                Nexthop Addr    State           Label      Req.ID    Attr
  10.0.1.0/31         connected  Established     impl-null  0
  10.0.1.0/31         connected  Established     none       0         None
  10.0.2.0/31         connected  Established     24322     0
  10.0.2.0/31         10.0.1.1  Established     impl-null  0
  10.0.3.0/31         connected  Established     24323     0
  10.0.3.0/31         10.0.4.1  Established     impl-null  0
  10.0.4.0/31         connected  Established     impl-null  0
  10.0.4.0/31         connected  Established     none       0         None
  11.1.1.1/32         connected  Established     none       0         None
  22.1.1.1/32         10.0.1.1  Established     impl-null  0
  33.1.1.1/32         10.0.4.1  Established     24323     0
  33.1.1.1/32         10.0.1.1  Established     24324     0
  44.1.1.1/32         10.0.4.1  Established     impl-null  0
  192.168.254.0/24    connected  Established     impl-null  0
  192.168.254.0/24    connected  Established     impl-null  0
  192.168.254.0/24    connected  Established     none       0         None

UPSTREAM LSP :
```

FEC	State	Label	Req.ID	Attr
10.0.1.0/31	Established	impl-null	0	None
10.0.1.0/31	Established	impl-null	0	None
10.0.2.0/31	Established	24320	0	None
10.0.3.0/31	Established	24321	0	None
10.0.4.0/31	Established	impl-null	0	None
10.0.4.0/31	Established	impl-null	0	None
11.1.1.1/32	Established	impl-null	0	None
11.1.1.1/32	Established	impl-null	0	None
22.1.1.1/32	Established	24322	0	None
44.1.1.1/32	Established	24324	0	None
192.168.254.0/24	Established	impl-null	0	None
192.168.254.0/24	Established	impl-null	0	None

When LDP LFA FRR is enabled:

```
#show ldp lsp
DOWNSTREAM LSP :
```

FEC	Nexthop Addr	State	Label	Req.ID	Attr	Code
10.0.1.0/31	connected	Established	impl-null	0		
10.0.1.0/31	connected	Established	none	0	None	
10.0.2.0/31	connected	Established	24322	0		
10.0.2.0/31	10.0.4.1	Established	24322	0		B
10.0.2.0/31	10.0.1.1	Established	impl-null	0		P
10.0.3.0/31	connected	Established	24323	0		
10.0.3.0/31	10.0.1.1	Established	24323	0		B
10.0.3.0/31	10.0.4.1	Established	impl-null	0		P
10.0.4.0/31	connected	Established	impl-null	0		
10.0.4.0/31	connected	Established	none	0	None	
11.1.1.1/32	connected	Established	none	0	None	
22.1.1.1/32	10.0.1.1	Established	impl-null	0		P
33.1.1.1/32	10.0.4.1	Established	24323	0		P
33.1.1.1/32	10.0.4.1	Established	24323	0		B
33.1.1.1/32	10.0.1.1	Established	24324	0		P
33.1.1.1/32	10.0.1.1	Established	24324	0		B
44.1.1.1/32	10.0.4.1	Established	impl-null	0		
192.168.254.0/24	connected	Established	impl-null	0		
192.168.254.0/24	connected	Established	impl-null	0		
192.168.254.0/24	connected	Established	none	0	None	

```
UPSTREAM LSP :
```

FEC	State	Label	Req.ID	Attr
10.0.1.0/31	Established	impl-null	0	None
10.0.1.0/31	Established	impl-null	0	None
10.0.2.0/31	Established	24320	0	None
10.0.3.0/31	Established	24321	0	None
10.0.4.0/31	Established	impl-null	0	None
10.0.4.0/31	Established	impl-null	0	None
11.1.1.1/32	Established	impl-null	0	None
11.1.1.1/32	Established	impl-null	0	None
22.1.1.1/32	Established	24322	0	None

44.1.1.1/32	Established	24324	0	None
192.168.254.0/24	Established	impl-null	0	None
192.168.254.0/24	Established	impl-null	0	None

Table 2-10 explains the show command output fields.

Table 2-10: show ldp lsp output fields details

Field	Description
Session peer	Used to group and apply the configuration of general session commands to groups of neighbors that share common session configuration elements.
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
Nexthop addr	Displays the IP address of the next hop.
State	Displays the current status of the ldp.
Label	Details of the ldp downstream labels.
Req.ID	Request identifier for the protocol.
Attr	The attribute is used to sent to a customer router.
Code	Show if an entry is principal or backup.

show ldp mpls-l2-circuit

Use this command to display summarized Layer-2 Virtual Circuit information about all MPLS virtual circuits configured on the current LSR. When the Virtual Circuit ID is specified, this command displays summarized information for the Virtual Circuit matching the specified ID only.

Command Syntax

```
show ldp mpls-l2-circuit
show ldp mpls-l2-circuit <1-4294967295>
show ldp mpls-l2-circuit detail
show ldp mpls-l2-circuit count
show ldp mpls-l2-circuit <1-4294967295> detail
```

Parameter

<1-4294967295> Indicates the virtual circuit ID.

detail Displays detailed LDP information.

count Count of PWs from LDP standpoint.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output of this command displaying summarized information of VID 1000:

```
#show ldp mpls-l2-circuit 1000
Transport Client    VC      Trans    Local    Remote    Destination
VC ID   Binding   State   Type     VC Label  VC Label  Address
1000    eth2      UP      ethernet 640       640       192.168.0.80

#show ldp mpls-l2-circuit
Transport Client    VC      Trans    Local    Remote    Destination
VC ID   Binding   State   Type     VC Label  VC Label  Address
1000    eth2      UP      ethernet 640       640       192.168.0.80
2000    eth3      UP      ethernet 641       648       192.168.0.80
3000    eth4      UP      ethernet 642       645       192.168.0.90
```

The following is a sample output of this command when using the detail parameter:

```
#show ldp mpls-l2-circuit detail
vcid: 100, type: ethernet, local groupid: 4, remote groupid: 4 (vc is up)
destination: 10.0.0.2, Peer LDP Ident: 10.0.0.2
Local label: 53120, remote label: 53120
Access IF: eth3, Network IF: eth4
Local MTU: 1500, Remote MTU: 1500
Local Control Word: 0, Remote Control Word: 0
Local PW Status Capability : enabled
```

```

Remote PW Status Capability : enabled
Current PW Status TLV : enabled
Local PW Status :
Not Forwarding
Remote PW Status :
Not Forwarding
Standby

```

Table 2-11 explains the show command output fields.

Table 2-11: show ldp mpls-l2-circuit output fields details

Field	Description
Transport VC ID	Transport VC identifier for the protocol.
Client Binding	Show whether the interface is client bound and (if bound) with which client.
VC State	State of the VC.
Trans Type	Type of transmit.
Local VC Label	Incoming VC label details.
Remote VC Label	Outgoing VC label details.
Destination Address	Destination IP address for the protocol.
VCid	Address for the VC.
Type	Type of Ethernet interface.
local groupid	Address for the local group.
remote groupid	Address for the remote group.
destination	Destination IP address.
Peer LDP Ident	Identification for the peer LDP.
Local label	Number of Local label
remote label	Number remote label.
Access IF	Map the access port.
Network IF	Map the network port in the interface.
Local MTU	Number of local MTU., Remote MTU - Number of local MTU.
Local Control Word	Number of local control word.
Remote Control Word	Number of local control word.
Local PW Status Capability	PW Status capability of Local end of PW.

Table 2-11: show ldp mpls-l2-circuit output fields details (Continued)

Field	Description
Remote PW Status Capability	PW Status capability of Remote end of PW.
Current PW Status TLV	A data structure used to encode optional information in a data communications protocol.
Local PW Status	PW Status of Local end of PW.
Remote PW Status	PW Status of Remote end of PW.

show ldp rlfa-routes

Use this command to display LDP remote LFA routes.

Command Syntax

```
show ldp rlfa-routes
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#show ldp rlfa-routes
Fec          Primary-NH      Backup-NH      rLFA-Addr      Out-Intf  Outer-
label  Inner-label
2.2.2.2      20.1.1.1      30.1.1.1      1.1.1.1      xe5
24320        24324
3.3.3.3      30.1.1.1      20.1.1.1      1.1.1.1      xe12
24320        24325
```

show ldp routes

Use this command to display LDP routes.

Command Syntax

```
show ldp routes
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3 and was updated in OcNOS version 5.1.

Example

When LDP LFA FRR in not enabled:

```
#show ldp routes
Prefix Addr      Nexthop Addr      Intf
10.0.1.0/31      0.0.0.0           eth2
10.0.2.0/31      10.0.1.1          eth2
                  10.0.4.1          eth1
10.0.3.0/31      10.0.4.1          eth1
                  10.0.1.1          eth2
10.0.4.0/31      0.0.0.0           eth1
11.1.1.1/32      0.0.0.0           lo
22.1.1.1/32      10.0.1.1          eth2
33.1.1.1/32      10.0.1.1          eth2
                  10.0.4.1          eth1
44.1.1.1/32      10.0.4.1          eth1
192.168.254.0/24 0.0.0.0           eth0
```

When LDP LFA FRR in enabled:

```
#show ldp routes
Prefix Addr      Nexthop Addr      Intf      Backup Addr      Backup Intf
10.0.1.0/31      0.0.0.0           eth2      -               -
10.0.2.0/31      10.0.1.1          eth2      10.0.4.1        eth1
10.0.3.0/31      10.0.4.1          eth1      10.0.1.1        eth2
10.0.4.0/31      0.0.0.0           eth1      -               -
11.1.1.1/32      0.0.0.0           lo        -               -
22.1.1.1/32      10.0.1.1          eth2      -               -
33.1.1.1/32      10.0.1.1          eth2      10.0.4.1        eth1
                  10.0.4.1          eth1      10.0.1.1        eth2
44.1.1.1/32      10.0.4.1          eth1      -               -
192.168.254.0/24 0.0.0.0           eth0      -               -
```

Table 2-12 explains the show command output fields.

Table 2-12: show ldp routes output fields details

Prefix Addr	Details of the network address prefix.
Nexthop Addr	Displays the IP address of the next hop.
Intf	Displays an interface name.
Backup Addr	Displays the IP address of the backup next hop.
Backup Intf	Displays a backup interface name.

show ldp routes count

Use this command to display the ldp route count.

Command Syntax

```
show ldp routes count
```

Parameter

count	Counts the no of ldp routes
-------	-----------------------------

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 6.5.4.

Example

```
PE2#show ldp routes count
```

```
-----  
Total no of LDP routes : 8  
-----
```

show ldp rlfa-routes count

Use this command to display ldp rlfa routes count.

Command Syntax

```
show ldp rlfa-routes count
```

Parameter

count	Counts the no of ldp-rlfa routes
-------	----------------------------------

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 6.5.4.

Example

```
PE2#show ldp rlfa-routes count
-----
Total no of ldp-rlfa routes : 4
-----
```

show ldp session

Use this command to display sessions established between this LSR and other LSRs.

Command Syntax

```
show ldp session
show ldp session A.B.C.D
show ldp session X:X::X:X
show mpls ldp session
show mpls ldp session A.B.C.D
show mpls ldp session X:X::X:X
```

Parameter

A.B.C.D	IPv4 address of the peer.
X:X::X:X	IPv6 address of the peer.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
OcNOS#show ldp session 192.168.3.5
Session state: OPERATIONAL
Session role: Passive
TCP Connection: Established
IP Address for TCP: 192.168.3.5
Interface being used : eth1
Peer LDP ID: 10.10.0.18:0
Peer Password : mypwd
Authentication type: MD5
Adjacencies: 192.168.3.5
192.168.4.5
Advertisement mode: Downstream Unsolicited
Label retention mode : Liberal
Graceful Restart           : Capable
Reconnect Timeout          : 120
Recovery Timeout (max)     : 120
Recovery Timeout [negotiated] : 0 [120]
Keepalive Timeout: 30
Reconnect Interval: 15
Address List received : 192.168.3.5
192.168.4.5
Received Labels :FecLabelMaps To
IPV4:10.10.0.0/24
impl-null none
IPV4:192.168.3.0/24 impl-null none
IPV4:192.168.4.0/24 impl-null none
```

```

IPV4:192.168.5.0/24 impl-null none
Sent Labels :FecLabelMaps To
IPV4:10.10.0.0/24
impl-null none
IPV4:192.168.3.0/24 impl-null none
IPV4:192.168.4.0/24 impl-null none

```

Table 2-13 explains the show command output fields.

Table 2-13: show ldp session output fields details

Field	Description
Session state	Reports the current session state.
Session role	Displays the status of the session role.
TCP Connection	Details of the TCP connection.
IP Address for TCP	Transmission control protocol IP address for the network.
Interface	Name of interface used in the network.
Peer LDP ID	Identifier for the peer LDP.
Peer Password	Credential details for the neighbor.
Authentication type	Type of authentication.
Adjacencies	IP address for the neighbor adjacencies.
Advertisement mode	Details of the advertisement mode.
Label retention mode	Details of the label retention mode.
Graceful Restart	Indicates if the peer session is “Capable” or “Not Capable”.
Reconnect Timeout	The amount of time the router keeps the labels until session re-connection, the value is the lower value between local and remote neighbor-liveness timer. It appears when the session is GR capable.
Recovery Timeout (max)	Indicates the amount of time for the recovery session to send the initialization message to the peer, according to the local max-recovery timer. It appears when the session is GR capable.
Recovery Timeout [negotiated]	Indicates the actual timer value and the initial amount of time to recovery session (between brackets) that is negotiated with the peer to the lower value between local and remote values. Negotiated value 0 indicates the labels are not preserved after session disconnection. It appears when the session is GR capable.
Keepalive Interval	Used to set the interval for sending keep-alive messages to the peer in order to maintain a session.
Keepalive Timeout	Time-out value for rejecting a session with a peer.
Address List received	List of address that is received from neighbor.
Received Labels	Number of labels received from neighbor session.
Sent Labels	Number of labels transmitted to neighbor session.

show ldp statistics

Use this command to display LDP statistics.

Command Syntax

```
show ldp statistics
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output from the `show ldp statistics` command.

```
#show ldp statistics

=====
LSR ID = 0.0.0.0:0 : TARGETED PEER: 10.10.10.10
=====
PacketType                Total
                        Sent      Received
Notification                0          0
Hello                       0          0
Initialization              0          0
Keepalive                   0          0
Address                     0          0
Address Withdraw            0          0
Label Mapping               0          0
Label Request               0          0
Label Withdraw              0          0
Label Release               0          0
Request Abort               0          0
=====
#
```

[Table 2-14](#) explains the show command output fields.

Table 2-14: show ldp statistics output fields details

Field	Description
LSR ID	Identifier of the LSR.
Targeted Peer	Targeted LDP neighbor can improve the label convergence time compared to the convergence time with directly connected LDP peers when there are flapping links.

Table 2-14: show ldp statistics output fields details (Continued)

Field	Description
Packet Type	Type of packet in the interface that has been received or transmitted to the neighbors.
Total	Number of total packets that has been received and transmitted.

show ldp statistics advertise-labels

Use this command to display the count per each operation filtered by an advertisement list.

Command Syntax

```
show ldp statistics advertise-labels
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output from the `show ldp statistics advertise-labels` command.

```
#show ldp statistics advertise-labels
Advertisement spec:
  Prefix list = pfx1; Peer plist = pfx1
  Deny : Label Mapping = 2
        Label Request = 0
  Prevent the distribution of any assigned labels
  Deny : Label Mapping = 9
        Label Request = 3
#
```

[Table 2-15](#) explains the show command output fields.

Table 2-15: show ldp statistics advertise-labels output fields details

Field	Description
Advertisement spec	Details of the advertisement spec.
Prefix list	It is an ordered list and entries are evaluated in order of increasing sequence number.
Peer plist	The peer keyword enables the device to receive time requests and used to synchronize itself to the servers specified in the access list.
Label Mapping	Number of label mapping that is denied.
Label Request	Number of label request that is denied.

show ldp targeted-peers

Use this command to display the list of targeted peers configured on the current LSR.

Command Syntax

```
show ldp targeted-peers
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output from the `show ldp targeted-peers` command.

```
#show ldp targeted-peers
IP Address      Interface
192.168.201.2   eth1
```

[Table 2-16](#) explains the show command output fields.

Table 2-16: show ldp targeted-peers output fields details

Field	Description
IP Address	Internet protocol address for the interface.
Interface	Name of the interface.

show ldp label-pool

Use this command to display the label management in LDP protocol.

Command Syntax

```
show ldp label-pool (block-id <0-1638>|)
```

Parameters

block-id Block identifier of a block that is allocated to the protocol

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 6.5.4.

Example

```
show ldp label-pool
Module: LDP, Label range: 16-1048575, Current block: 40
+-----+-----+-----+-----+-----+-----+-----+
---+
block_id label_min label_max usable_labels free_labels first_free_label
+-----+-----+-----+-----+-----+-----+-----+
---+
40 25600 26239 640 628 25612
Total - blocks: 1, used-labels: 12, free-labels: 628
Module: LDP-VC, Label range: 16-1048575, Current block: 79
+-----+-----+-----+-----+-----+-----+-----+
---+
block_id label_min label_max usable_labels free_labels first_free_label
+-----+-----+-----+-----+-----+-----+-----+
---+
41 26240 26879 640 0 0
79 50560 51199 640 456 50744
Total - blocks: 2, used-labels: 824, free-labels: 456
```

show ldp tunneling

Use this command to display TE-tunnels enabled for tunneling LDP FECs.

Command Syntax

```
show ldp tunneling (TRUNKNAME|)
```

Parameter

TRUNKNAME The trunk name is an optional parameter and represents the name of the trunk for which the details need to be displayed.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS Version 6.5.3.

Example

The following is a sample output of the `show ldp tunneling` command showing the status of all upstream sessions.

```
(OcNOS)#show ldp tunneling
```

```
Tunnel Name       : PE2-PE4
```

```
Tunnel Endpoint   : 10.12.183.4/32
```

```
Tunnel Cost       : 10
```

```
Tunnel Owner      : RSVP
```

```
Tunnel Status     : Up
```

```
FEC                Upstream-Peer   In-Label   Out-Label
```

```
=====
```

```
10.12.183.5/32     10.12.183.1    25029      24989
```

```
10.12.183.6/32     10.12.183.1    25030      24990
```

```
Total FEC tunneld by PE2-PE4 : 2 6
```

show ldp tunneling-fec

Use this command to display LDP FECs which are mapped to TE-tunnel for tunneling LDP over RSVP.

Command Syntax

```
show ldp tunneling-fec
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS Version 6.5.3.

Example

The following is a sample output of the `show ldp tunneling-fec` command showing the status of all upstream sessions.

```
(OcNOS) # show ldp tunneling-fec
```

FEC	Tunnel-name		Tunnel-endpoint
Upstream-Peer	In-label	Out-label	
=====			
10.12.183.5/32	PE2-PE4		10.12.183.4/32
10.12.183.1	25029	24989	
10.12.183.6/32	PE2-PE4		10.12.183.4/32
10.12.183.1	25030	24990	

show ldp tunneling-tunnels

Use this command to display all TE-tunnels which are enabled for tunneling LDP FECs.

Command Syntax

```
show ldp tunneling-tunnels
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS Version 6.5.3.

Example

The following is a sample output of the `show ldp tunneling-tunnels` command showing the status of all upstream sessions.

```
(OcNOS) # show ldp tunneling-tunnels
```

Tunnel-name	Tunnel-endpoint	Status	Cost
=====			
PE2-PE4	10.12.183.4/32	Up	10
PE2-PE5	10.12.183.5/32	Up	20

show ldp vpls

Use this command to display information about all VPLS instances. Specify the VPLS ID to display information about a specific VPLS instance.

Command Syntax

```
show ldp vpls <1-4294967295> (count|)
show ldp vpls count
show ldp vpls detail
show ldp vpls (no-vc|)
```

Parameter

<1-4294967295>	Display the VPLS identifier.
count	Display VPLS count from LDP standpoint.
detail	Display detailed LDP VPLS information.
no-vc	Specify not display L2VC information.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output of the `show ldp vpls` command displaying information about all VPLS instances.

```
#show ldp vpls
VPLS-ID      Peer Address      State  Type      Label-Sent  Label-Rcvd
1            192.168.0.80      Up     vpls      16          640
1            192.168.0.90      Up     vpls      18          642
2            192.168.0.80      Up     vpls      19          641
2            192.168.0.90      Up     vpls      17          643
```

The following is an output of the `show ldp vpls detail` command:

```
#show ldp vpls detail
VPLS Identifier      : 1
Peer IP              : 192.168.0.80
VC State             : UP
VC Type              : vpls
VC Label Sent        : 16
VC Label Received    : 640

VPLS Identifier      : 1
Peer IP              : 192.168.0.90
VC State             : UP
VC Type              : vpls
VC Label Sent        : 18
VC Label Received    : 642
```

```

VPLS Identifier      : 2
Peer IP              : 192.168.0.80
VC State             : UP
VC Type              : vpls
VC Label Sent        : 19
VC Label Received    : 641

```

The following is a sample output of `show ldp vpls count` displaying information about total, active and inactive VPLS instances from LDP.

```

#show ldp vpls count
-----
Total VPLS instances      : 2
Active VPLS instances     : 2
Inactive VPLS instances   : 0
-----

```

[Table 2-17](#) explains the show command output fields.

Table 2-17: show ldp vpls output fields details

Field	Description
VPLS-ID	Identification details of the VPLS.
Peer Addr	IP address of the peer device.
State	Reports the current session state.
Type	Type of protocol in network.
Label-Sent	Number of packets transmitted to neighbor.
Label-Rcvd	Number of packets received from neighbor.
Total VPLS instances	Number of total VPLS instance in the protocol.
Active VPLS instances	Number of active VPLS instance.
Inactive VPLS instances	Number of inactive VPLS instance.

show mpls ldp discovery

Use this command to display the sources for locally generated LDP Discovery Hello PDUs, and to indicate whether an interface is label-switching.

Command Syntax

```
show mpls ldp discovery
show mpls ldp discovery IFNAME
```

Parameter

IFNAME Interface name.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls ldp discovery
InterfaceLDP IdentifierLabel-switchingMerge Capability
eth010.10.0.11:0DisabledN/A
lo10.10.0.11:0DisabledN/A
eth110.10.0.11:0Enabled Merge capable
eth210.10.0.11:0Enabled Merge capable
vmnet110.10.0.11:0 Disabled N/A
```

[Table 2-18](#) explains the show command output fields.

Table 2-18: show ldp discovery output fields details

Field	Description
Interface	Name of the interface.
LDP Identifier	LDP identifier for this protocol.
Label-switching	Status of the label-switching on interface.
Merge Capability	Used to override the default merge capability setting of all the interfaces.

show mpls ldp neighbor

Use this command to display LDP neighbor information.

Command Syntax

```
show mpls ldp neighbor
show mpls ldp neighbor detail
```

Parameter

detail Details for adjacencies.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls ldp neighbor detail
IP AddressInterface NameHoldtimeLDP ID
192.168.3.5eth11510.10.0.18:0
192.168.4.5eth21510.10.0.18:0
```

[Table 2-19](#) explains the show command output fields.

Table 2-19: show mpls ldp neighbor output fields

Field	Description
IP Address	Address of the interface.
Interface Name	Name of the interface.
Holdtime	The amount of time this device waits between SPF.
LDP ID	Local label space ID. The first four bytes of an LDP ID is a platform IP address called the LDP router ID. The last two bytes are called the local label space ID.

show mpls ldp parameter

Use this command to display LDP configuration parameters.

Command Syntax

```
show mpls ldp parameter
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls ldp parameter
Router ID           : 0.0.0.0
LDP Version         : 1
Global Merge Capability : Merge Capable
Label Advertisement Mode : Downstream Unsolicited
Label Retention Mode  : Liberal
Label Control Mode    : Independent
Instance Loop Detection : Off
Request Retry         : Off
Propagate Release     : Disabled
Graceful Restart      : Disabled
Hello Interval        : 5
Targeted Hello Interval : 15
Hold time             : 15
Targeted Hold time    : 45
Keepalive Interval    : 10
Keepalive Timeout     : 30
Request retry Timeout  : 5
Transport Address data :
  Labelspace 0        : 192.168.201.2 (not in use)
Import BGP routes     : No
```

Table 2-20 explains the show command output fields.

Table 2-20: show mpls ldp parameters output fields

Field	Description
Router ID	A preferred interface address for LDP router.
LDP Version	Latest LDP version details.

Table 2-20: show mpls ldp parameters output fields

Field	Description
Global Merge Capability	Override the default merge capability setting of all the interfaces.
Label Advertisement mode	Label advertisement mode details in the interface.
Label retention mode	Label retention mode details in the interface.
Label Control Mode	Controls the mode used for handling label binding requests on interfaces.
Instance Loop Detection	Disables the LDP optional loop detection mechanism.
Request Retry	Request causes the target peer to respond with targeted Hello messages.
Propagate Release	Propagate release is disabled in the interface.
Graceful Restart	Graceful Restart (GR) is a mechanisms to prevent routing protocol re-convergence during a processor switchover. Hello Interval - Hello interval sets the interval for sending unicast hello packets to peers.
Targeted Hello Interval	Targeted hello interval sets the interval for sending unicast hello packets to targeted peers.
Hold time	Hold time sets the time-out value to peers.
Targeted Hold time	Time-out value is the time that the router waits before rejecting an adjacency with targeted peers.
Keepalive Interval	Keepalive interval sets the interval for sending keep-alive messages to the peer in order to maintain a session.
Keepalive Timeout	Time-out value for rejecting a session with a peer.
Request retry Timeout	Request for the maximum retry duration (the number of retries times the length of the timeout).
Transport Address data	Transport address advertised in LDP Discovery Hello messages sent on an interface.
Label space	Label used in a label binding is allocated from a set of possible labels called a label space.
Import BGP routes	The BGP Support for IP Prefix Import from Global Table into a VRF Table feature introduces the capability to import IPv4 unicast prefixes from the global routing table into a Virtual Private Network (VPN) routing/forwarding (VRF) instance table using an import route map.

Resource Reservation Protocol Configuration

CHAPTER 1 RSVP-TE Configuration

This chapter contains configurations for Resource Reservation Protocol - Traffic Engineering (RSVP-TE).

RSVP-TE Overview

RSVP-TE is a signaling protocol that supports explicit routing capabilities. To do this, an Explicit Route (ER) object is incorporated into RSVP PATH messages. This object encapsulates a sequence of hops that constitute the explicitly-routed path. Using the ER object, the paths taken by label-switched RSVP-MPLS flows can be pre-determined without conventional IP routing. An ER path can be administratively specified or computed based on CSPF and any policy requirements dictated by the operator through the trunk node, taking the current network state into consideration. A useful application of explicit routing is Traffic Engineering (TE). Using explicitly-routed LSPs, an ingress node can control the path through which traffic flows from itself, through the MPLS network, to the egress node. Explicit routing is therefore useful for the optimization of network resources and an increase in the quality of traffic-oriented performance.

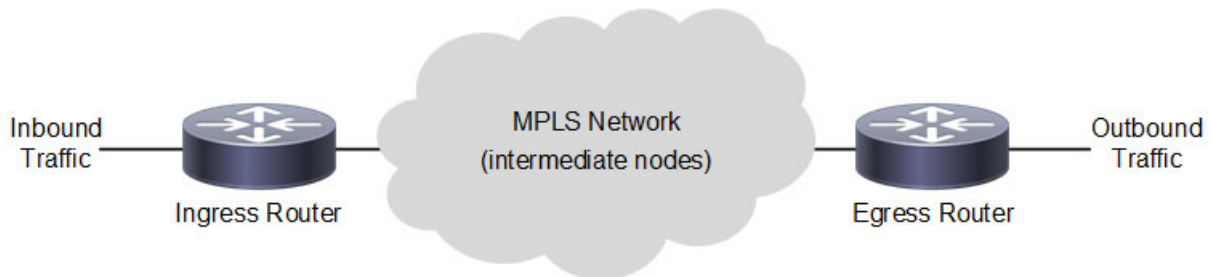


Figure 1-11: Basic RSVP-TE Topology

RSVP-TE Architecture

RSVP-TE is a signaling protocol that supports explicit routing capabilities to establish LSPs in a MPLS network. OcNOS RSVP-TE:

- Creates explicitly-routed paths, which might not agree with the route suggested by the IGP (OSPF, RIP) being used. Explicitly-routed LSPs, by definition, do not follow the paths suggested by IGPs.
- Queries CSPF for a complete, end-to-end, explicit route based on constraints specified by the operator using RSVP commands.
- Performs make-before-break type re-routing of tunnels. (Make-before-break is the creation of a new LSP before the old one is torn down).
- Exchanges Hello messages to make node failures easier to detect. This means when there is no hello exchange between routers, then other node is assumed dead or offline (except in the case when the peer is known to not support Hellos).
- Provides statistical information of RSVP messages exchanged.

In addition, OcNOS RSVP-TE may be used in unison with BGP to generate MPLS/BGP VPNs, and in unison with LDP to generate Layer-2 Virtual Circuits.

Configure RSVP-TE

Note: The following configuration for establishing a trunk is required on all routers participating in label-switching. Based on the assumption that minimal configurations exist on all participating routers, other examples do not repeat this configuration.

Enable Label Switching - Minimal Configuration

To establish a trunk on a system:

- 1. Enable label-switching and RSVP-TE on all participating interfaces.
- 2. Configure a trunk on the ingress router to use the best available IGP path.

In this example, the Label Switched Path (LSP) is configured using minimal configuration and is setup using the best IP nexthop available. Each router along the path is chosen by the previous router by looking up the best nexthop available in its IP routing table.

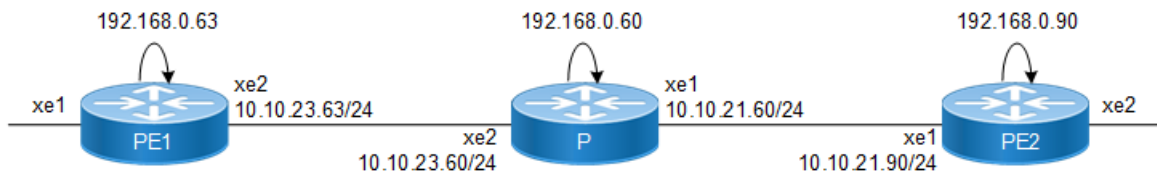


Figure 1-12: Topology for Minimal Configuration

PE1 - NSM

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 192.168.0.63/32 secondary	Set the IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 10.10.23.63/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#commit	Commit the transaction.

PE1 - RSVP-TE

(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#commit	Commit the transaction.

PE1 - OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 192.168.0.63	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.10.23.0/24 area 0	Define the network (10.10.23.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 192.168.0.63/32 area 0	Set the IP address of the loopback interface to 192.168.0.63/32.
(config-router)#commit	Commit the transaction.

P - NSM

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 192.168.0.60/32 secondary	Set the IP address for the interface.
(config-if)#exit	Enable label switching on interface lo.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 10.10.23.60/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.10.21.60/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#commit	Commit the transaction.

P - RSVP-TE

(config)#router rsdp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#commit	Commit the transaction.

P - OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 192.168.0.60	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.10.23.0/24 area 0	Define the first network (10.10.23.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 10.10.21.0/24 area 0	Define the second network (10.10.21.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 192.168.0.60/32 area 0	Set the IP address of the loopback interface to 192.168.0.63/32.
(config-router)#commit	Commit the transaction.

PE2 - NSM

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 192.168.0.90/32 secondary	Set the IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.10.21.90/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#commit	Commit the transaction.

PE2 - RSVP-TE

(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#commit	Commit the transaction.

PE2 - OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 192.168.0.90	Configure OSPF router-ID same as loopback interface IP address

<code>(config-router)#network 10.10.21.0/24 area 0</code>	Define the network (10.10.21.0/24) on which OSPF runs and associate the area ID (0).
<code>(config-router)#network 192.168.0.90/32 area 0</code>	Set the IP address of the loopback interface to 192.168.0.63/32.
<code>(config-router)#commit</code>	Commit the transaction.

Establish a Trunk with CSPF Disabled

OcNOS, Constrained Shortest Path First (CSPF) calculation is enabled by default. Typically, CSPF is disabled when all of the participating nodes do not support the required traffic engineering extensions and LSPs are configured manually to use an explicit path. In this case, an LSP is established only along the path specified by the operator.

Note: This example is based on the assumption that a minimal configuration exists on all participating routers as described in [Enable Label Switching - Minimal Configuration](#).

Topology

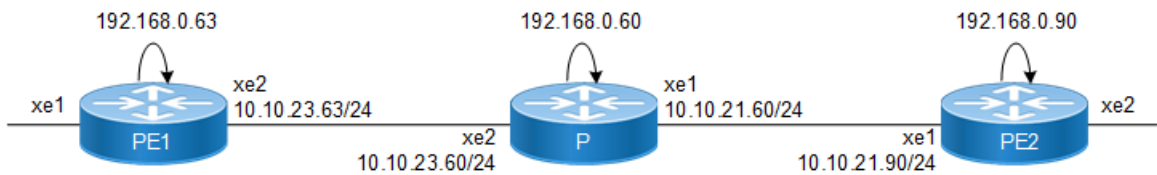


Figure 1-13: Basic Topology

PE1 - RSVP-TE

<code>#configure terminal</code>	Enter configure mode.
<code>(config)#rsvp-trunk T1</code>	Create an RSVP trunk T1 and enter the Trunk mode.
<code>(config-trunk)#no primary cspf</code>	Specify no primary cspf since CSPF is enabled by default.
<code>(config-trunk)#to 192.168.0.90</code>	Specify the IPv4 egress (destination point) for the LSP.
<code>(config-trunk)#commit</code>	Commit the transaction.

Establish a Trunk Using CSPF

The RSVP trunk can be configured using CSPF (Constraint-based Shortest Path First). In this case, the RSVP daemon (rsvpd) sends a request to the CSPF server to compute a path through the network to reach the destination. CSPF returns a hop-by-hop path called the Explicit Route to the RSVP daemon to be used in the Explicit Route Object (ERO). Each router along the path sends a Path message only to the nexthop specified in the ERO. In the OcNOS implementation, CSPF is enabled by default and if no cspf is not specified, the trunk is CSPF enabled automatically.

Note: This example is based on the assumption that a minimal configuration exists on all participating routers as described in [Enable Label Switching - Minimal Configuration](#).

PE1 (RSVP Daemon)

<code>#configure terminal</code>	Enter configure mode.
<code>(config)#rsvp-trunk T1</code>	Create an RSVP trunk T1 and enter the Trunk mode.

(config-trunk)#to 192.168.0.90	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#commit	Commit the transaction.

Mapping a Route to a Trunk

In the OcNOS implementation, a network can be mapped to a particular trunk using map-route configuration.

Note: This example is based on the assumption that a minimal configuration exists on all participating routers. For configuration details, refer to the “Establishing a Trunk - Minimal Configuration” section.

Topology

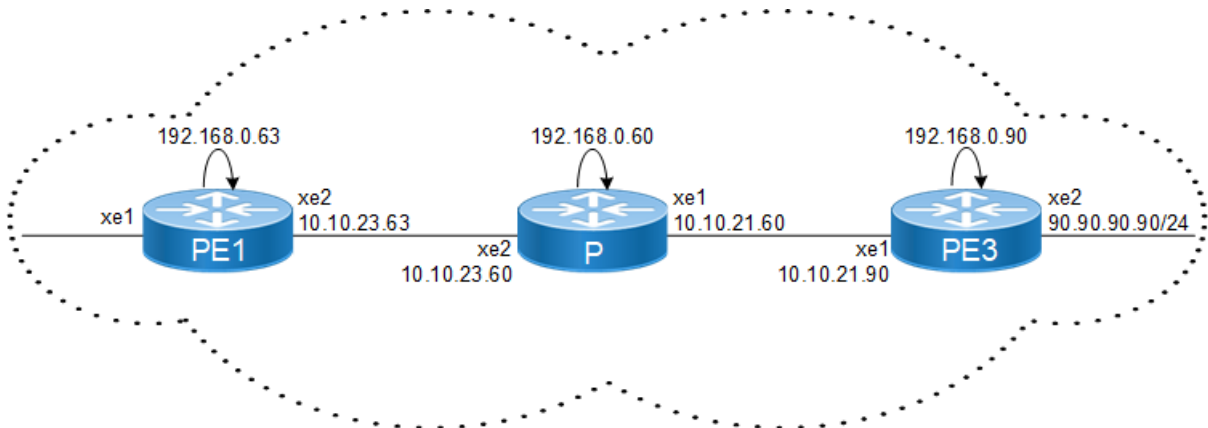


Figure 1-14: Topology for route mapping

PE1 - RSVP-TE

#configure terminal	Enter configure mode.
(config)#router rsvp	Enable RSVP globally.
(config-router)#rsvp-path PE2	Configure RSVP path.
(config-path)#rsvp-trunk T1	Create an RSVP trunk T1 and enter the Trunk mode.
(config-trunk)#map-route 90.90.90.0/24	Specify the destination prefix that needs to mapped to this trunk.
(config-trunk)#to 192.168.0.90	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#commit	Commit the transaction.

Establish a Trunk Using Explicitly-Defined Path

Explicit Route hops can be configured manually in the trunk configuration. In this case, the RSVP daemon uses the configured hops as Explicit Route Objects (ERO). It sets up the LSP using specified hops only.

An ERO is composed of IP addresses called hops. An ERO hop can be defined as loose or strict. A loose hop can be reached by any available route. A strict hop must be reached via a direct link and cannot be routed over any alternate routers in between. In this example, since PE3 is defined as loose hop, P can use P2 as an intermediate hop to reach PE2. However, if it was a strict hop, then P would have to use interface xe1 to reach PE3 directly.

Note: This example is based on the assumption that a minimal configuration exists on all participating routers as described in [Enable Label Switching - Minimal Configuration](#).

Topology

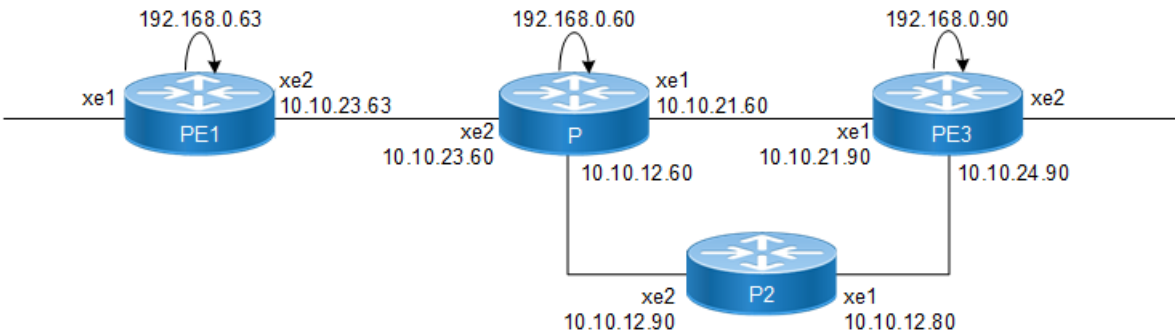


Figure 1-15: Topology for Explicitly Defined Path

PE1 - RSVP-Path

#configure terminal	Enter configure mode.
(config)#rsvp-path P1	Create an RSVP Path P1 and enter the Path mode.
(config-path)#10.10.23.60 strict	Configure this explicit route path as a strict hop.
(config-path)#10.10.21.90 loose	Configure this explicit route path as a loose hop.
(config-path)#exit	Exit Path mode.
#configure terminal	Enter configure mode.
(config)#rsvp-trunk T1	Create an RSVP trunk T1 and enter the Trunk mode.
(config-trunk)#no primary cspf	Since CSPF is enabled by default, specify no primary cspf if CSPF is not required.
(config-trunk)#primary path P1	Configure trunk T1 to use the defined path.
(config-trunk)#to 192.168.0.90	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#commit	Commit the transaction.

Validation

```
PE1#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To          From          Type    LSPName          State Uptime    Rt
Style Labelin Labelout DSType
192.168.0.90 192.168.0.63 PRI     T1-Primary       UP    00:00:16
1 1 SE      -          24320  DEFAULT
Total 1 displayed, Up 1, Down 0.

PE2#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
```

ondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Egress RSVP:
To From Type LSPName State Uptime Rt Style Labelin Labelout DStype
192.168.0.90 192.168.0.63 PRI T1-Primary UP 00:00:33 1 1 SE 25600 -
ELSP_CON

Total 1 displayed, Up 1, Down 0. PE1#show ip ospf neighbor
Total number of full neighbors: 1 OSPF process 100 VRF(default):
Neighbor ID Pri State Dead Time Address Interface Instance ID
192.168.0.60 1 Full/Backup 00:00:30 10.10.23.60 xe2 0

P1#show ip ospf neighbor

Total number of full neighbors: 2 OSPF process 100 VRF(default):
Neighbor ID Pri State Dead Time Address Interface Instance ID
192.168.0.90 1 Full/Backup 00:00:35 10.10.21.90 xe8 0
192.168.0.63 1 Full/DR 00:00:36 10.10.23.63 xe2 0

PE2#show ip ospf neighbor

Total number of full neighbors: 1 OSPF process 100 VRF(default):
Neighbor ID Pri State Dead Time Address Interface Instance ID
192.168.0.60 1 Full/DR 00:00:32 10.10.21.60 xe8 0

Add a Secondary LSP to the Trunk

Although the attributes of a Secondary LSP are independent of the Primary LSP, a Secondary LSP cannot be configured without first configuring a Primary LSP. In addition to information on how to configure a secondary LSP, this example illustrates how to define a non-default setup and the hold priority for an LSP. Setup and hold priorities are used to determine which LSP should be given a preference when competing for resources. Specifically, the setup priority of an un-established LSP is compared to the hold priorities of established LSPs, and the numerically lower one is given a preference. However, once the LSP is established, its setup priority is never used until it is pre-empted or reset and is being brought up again.

- Note: This example is based on the assumption that a minimal configuration exists on all participating routers as described in [Enable Label Switching - Minimal Configuration](#).
- Note: If user provides the RSVP path option for secondary, the primary path exclusion logic gets disabled. User needs to keep primary and secondary path mutually exclusive. Else, RSVP-Primary LSP and RSVP-Secondary LSP may select the same next hop, when RSVP is configured with "loose". Hence RSVP-Path first next-hop should be "strict".

PE1 - RSVP-TE

#configure terminal	Enter configure mode.
(config)#rsvp-path myPath	Specify an RSVP path to be used.
(config-path)#10.10.23.60 strict	Configure this explicit route path as a strict hop.
(config-path)#exit	Exit Path mode.
(config)#rsvp-path myPath2	Specify an RSVP path to be used.

(config-path)#10.10.23.60 loose	Configure this explicit route path as a loose hop.
(config-path)#exit	Exit Path mode.
(config)#rsvp-trunk T1	Create an RSVP trunk T1 and enter the Trunk mode.
(config-trunk)#no primary cspf	Since CSPF is enabled by default, specify no secondary cspf if CSPF is not required.
(config-trunk)#primary path myPath	Specify an RSVP path to be used.
(config-trunk)#no secondary cspf	Specify the no secondary cspf option for the Secondary LSP.
(config-trunk)#secondary path myPath2	Specify an RSVP path to be used.
(config-trunk)#to 192.168.0.90	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#commit	Commit the transaction.

Validation

This example shows the number of configured RSVP sessions in a router.

PE1

```
#show rsvp session count
Total configured: 1, Up 1, Down 0

Total ingress sessions: 1, Up 1, Down 0
Total transit sessions: 0, Up 0, Down 0
Total egress sessions: 0, Up 0, Down 0
```

PE2

```
#show rsvp session count
Total configured: 1, Up 1, Down 0

Total ingress sessions: 0, Up 0, Down 0
Total transit sessions: 0, Up 0, Down 0
Total egress sessions: 1, Up 1, Down 0
```

Add Multiple Secondary LSP to the trunk

RSVP Multiple Secondary feature tries to provide continuous protection when multiple failures happen. In majority scenarios, feature tries to provide seamless protection. This is a proprietary feature where user can configure multiple secondary sessions in a rsvp-trunk. Each secondary will be associated with a priority. Priority secondary sessions must be programmed with a predefined path. User can configure a maximum of five priority levels. Lowest priority number corresponds to highest priority. Highest priority session will be signaled to be programmed as secondary session. If highest priority session cannot come up, then next available secondary will be selected based on polling. During primary session fail-over, programmed secondary priority session will protect the primary and then goes for an MBB update to act as the primary session until primary comes up. Once the highest priority session comes up as acting primary session, next available secondary priority session will be programmed to signal and come up secondary. Re-optimization timer executed once in every 5 minutes to ensure the best priority session serves as secondary. Configuration updates on secondary priority configurations doesn't trigger MBB and session will be restarted. This example illustrates how to create SVI, enable IGP protocols and RSVP on SVI.

Note: Ensure that the VLAN is configured before creating SVI.

Topology

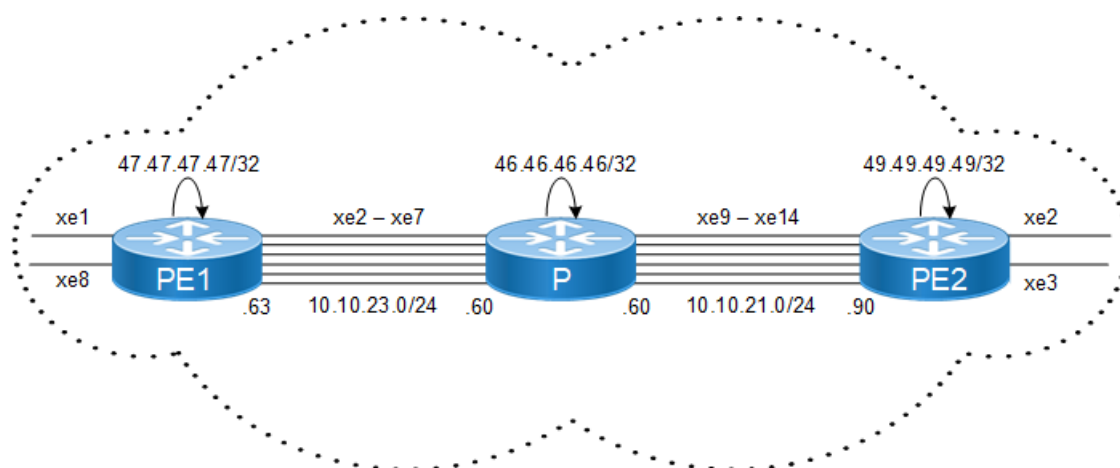


Figure 1-16: Topology for Multiple Secondary Protection

Bridge Configuration

```
bridge 1 protocol ieee vlan-bridge
no bridge 1 spanning-tree enable bridge-forward
```

VLAN creation

```
vlan database
vlan 2-7 bridge 1 state enable
vlan 501-506 bridge 1 state enable
```

PE1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 47.47.47.47/32 secondary	Set the secondary IP address for the lo interface
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enable RSVP globally.
(config-router)#exit	Exit RSVP mode.
(config)#interface vlan1.2	Enter the interface mode.
(config-if)#ip address 10.10.23.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.3	Enter the interface mode.
(config-if)#ip address 10.10.24.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.

(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.4	Enter the interface mode.
(config-if)#ip address 10.10.25.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.5	Enter the interface mode.
(config-if)#ip address 10.10.26.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.6	Enter the interface mode.
(config-if)#ip address 10.10.27.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.7	Enter the interface mode.
(config-if)#ip address 10.10.28.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface xe2	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 2,501	Configure allowed VLANs
(config-if)#switchport trunk native vlan 501	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.

(config)#interface xe3	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 3,502	Configure allowed VLANs
(config-if)#switchport trunk native vlan 502	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe4	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 4,503	Configure allowed VLANs
(config-if)#switchport trunk native vlan 503	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe5	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 5,504	Configure allowed VLANs
(config-if)#switchport trunk native vlan 504	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe6	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 6,505	Configure allowed VLANs
(config-if)#switchport trunk native vlan 505	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe7	Enter the interface mode.
(config-if)#switchport	Configure Switchport

(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 7,506	Configure allowed VLANs
(config-if)#switchport trunk native vlan 506	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(conf)#rsvp-path p1-r1-r3 mpls	Create RSVP path
(conf-path)#10.10.23.2 strict	Configure nexthop
(conf-path)#10.10.21.2 strict	Configure nexthop
(conf)#rsvp-path sp1-r1-r3 mpls	Create RSVP path
(conf-path)#10.10.24.2 strict	Configure nexthop
(conf-path)#10.10.22.2 strict	Configure nexthop
(conf)#rsvp-path sp2-r1-r3 mpls	Create RSVP path
(conf-path)#10.10.25.2 strict	Configure nexthop
(conf-path)#10.10.29.2 strict	Configure nexthop
(conf)#rsvp-path sp3-r1-r3 mpls	Create RSVP path
(conf-path)#10.10.26.2 strict	Configure nexthop
(conf-path)#10.10.30.2 strict	Configure nexthop
(conf)#rsvp-path sp4-r1-r3 mpls	Create RSVP path
(conf-path)#10.10.27.2 strict	Configure nexthop
(conf-path)#10.10.31.2 strict	Configure nexthop
(conf)#rsvp-path sp5-r1-r3 mpls	Create RSVP path
(conf-path)#10.10.28.2 strict	Configure nexthop
(conf-path)#10.10.32.2 strict	Configure nexthop
(conf)#rsvp-trunk 47-49-test ipv4	Create a RSVP trunk link
(conf-trunk)#primary path p1-r1-r3	Configure primary path for trunk link
(conf-trunk)#secondary-priority 1 path sp1-r1-r3	Configure secondary link for trunk link
(conf-trunk)#secondary-priority 2 path sp2-r1-r3	Configure secondary link for trunk link
(conf-trunk)#secondary-priority 3 path sp3-r1-r3	Configure secondary link for trunk link
(conf-trunk)#secondary-priority 4 path sp4-r1-r3	Configure secondary link for trunk link
(conf-trunk)#secondary-priority 5 path sp5-r1-r3	Configure secondary link for trunk link
(conf-trunk)#to 49.49.49.49	Configure remote node for the LSP
(config-trunk)#commit	Commit the transaction.

OSPF configurations

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 47.47.47.47	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.10.23.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.24.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.25.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.26.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.27.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.28.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 47.47.47.47/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router) #commit	Commit the transaction.

Validation

This example shows the number of configured RSVP sessions in a router.

PE1

```
#show rsvp session
```

```
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
```

```
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
```

```
* indicates the session is active with local repair at one or more nodes
```

```
(P) indicates the secondary-priority session is acting as primary
```

Ingress RSVP:

To Style	Labelin	From Labelout	Type DSType	LSPName	State	Uptime	Rt
49.49.49.49 1 1 SE	-	47.47.47.47 24961	PRI DEFAULT	47-49-test-Primary	UP	00:32:35	
49.49.49.49 1 1 SE	-	47.47.47.47 24962	SEC DEFAULT	47-49-test-Secondary-Priority-1	UP	00:32:35	

Total 2 displayed, Up 2, Down 0.

Egress RSVP:

To Style	Labelin	From Labelout	Type DSType	LSPName	State	Uptime	Rt
-------------	---------	------------------	----------------	---------	-------	--------	----

47.47.47.47	49.49.49.49	PRI	49-47-test-Primary	UP	00:32:53
1 1 SE	24964	-	ELSP_CON		
47.47.47.47	49.49.49.49	PRI	49-47-test-Secondary-Priority-1	UP	00:32:47
1 1 SE	24962	-	ELSP_CON		

Total 2 displayed, Up 2, Down 0.

#show rsvp trunk multi-sec-detail

Ingress (Secondary-Priority1)

49.49.49.49

From: 47.47.47.47, LSPstate: Up, LSPname: 47-49-test-Secondary-Priority-1

Ingress FSM state: Operational

Establishment Time: 0s 253ms

Setup priority: 7, Hold priority: 0

CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds

LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF

IGP-Shortcut: Disabled, LSP metric: 3

LSP Protection: None

Label in: -, Label out: 24962,

Tspec rate: 0, Fspec rate: 0

Policer: Not Configured

Tunnel Id: 5001, LSP Id: 2219, Ext-Tunnel Id: 47.47.47.47

Downstream: 47.46.3.2, vlan1.1003

Path refresh: 30 seconds (RR enabled) (due in 27970 seconds)

Resv lifetime: 157 seconds (due in 138 seconds)

Retry count: 0, intrvl: 30 seconds

RRO re-use as ERO: Disabled

Label Recording: Disabled

Admin Groups: none

Configured Path: SP1-47-49 (in use)

Configured Explicit Route Detail :

47.46.3.2/32 strict

46.45.9.2/32 strict

45.49.24.2/32 strict

Session Explicit Route Detail :

47.46.3.2/32 strict

46.45.9.2/32 strict

45.49.24.2/32 strict

Record route:

IP Address Label

<self>

47.46.3.2

46.45.9.2

45.49.24.2

Style: Shared Explicit Filter

Traffic type: controlled-load

Minimum Path MTU: 9216

Last Recorded Error Code: None

Last Recorded Error Value: None

Node where Last Recorded Error originated: None

```
Trunk Type: mpls
Ingress (Secondary-Priority2)
49.49.49.49
  From: 47.47.47.47, LSPstate: Dn, LSPname: 47-49-test-Secondary-Priority-2
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
  IGP-Shortcut: Disabled, LSP metric: 3
  LSP Protection: None
  Label in: -, Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2223, Ext-Tunnel Id: 47.47.47.47
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Secondary-Priority3)
49.49.49.49
  From: 47.47.47.47, LSPstate: Dn, LSPname: 47-49-test-Secondary-Priority-3
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -, Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2219, Ext-Tunnel Id: 47.47.47.47
  Last Recorded Error Code: Routing Problem (24)
  Last Recorded Error Value: No route available toward destination (5)
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Secondary-Priority4)
49.49.49.49
  From: 47.47.47.47, LSPstate: Dn, LSPname: 47-49-test-Secondary-Priority-4
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -, Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2219, Ext-Tunnel Id: 47.47.47.47
  Last Recorded Error Code: Routing Problem (24)
  Last Recorded Error Value: No route available toward destination (5)
```

```

Node where Last Recorded Error originated: None
Trunk Type: mpls
Ingress (Secondary-Priority5)
49.49.49.49
  From: 47.47.47.47, LSPstate: Dn, LSPname: 47-49-test-Secondary-Priority-5
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -, Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2219, Ext-Tunnel Id: 47.47.47.47
  Last Recorded Error Code: Routing Problem (24)
  Last Recorded Error Value: No route available toward destination (5)
  Node where Last Recorded Error originated: None
  Trunk Type: mpls

```

P Bridge Configuration

```

bridge 1 protocol ieee vlan-bridge
no bridge 1 spanning-tree enable bridge-forward

```

VLAN creation (Peer configuration for PE1)

```

vlan database
vlan 2-7 bridge 1 state enable
vlan 507-512 bridge 1 state enable

```

VLAN creation (Peer configuration for PE2)

```

vlan database
vlan 9-14 bridge 1 state enable
vlan 513-518 bridge 1 state enable

```

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 46.46.46.46/32 secondary	Set the secondary IP address for the lo interface
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enable RSVP globally.
(config-router)#exit	Exit RSVP mode.
(config)#interface vlan1.2	Enter the interface mode.
(config-if)#ip address 10.10.23.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.

(config)#interface vlan1.3	Enter the interface mode.
(config-if)#ip address 10.10.24.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.4	Enter the interface mode.
(config-if)#ip address 10.10.25.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.5	Enter the interface mode.
(config-if)#ip address 10.10.26.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.6	Enter the interface mode.
(config-if)#ip address 10.10.27.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.7	Enter the interface mode.
(config-if)#ip address 10.10.28.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.9	Enter the interface mode.
(config-if)#ip address 10.10.21.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.

(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.10	Enter the interface mode.
(config-if)#ip address 10.10.22.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.11	Enter the interface mode.
(config-if)#ip address 10.10.29.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.12	Enter the interface mode.
(config-if)#ip address 10.10.30.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.13	Enter the interface mode.
(config-if)#ip address 10.10.31.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.14	Enter the interface mode.
(config-if)#ip address 10.10.32.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface xe2	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk

(config-if)#switchport trunk allowed vlan add 2,507	Configure allowed VLANs
(config-if)#switchport trunk native vlan 507	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe3	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 3,508	Configure allowed VLANs
(config-if)#switchport trunk native vlan 508	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe4	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 4,509	Configure allowed VLANs
(config-if)#switchport trunk native vlan 509	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe5	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 5,510	Configure allowed VLANs
(config-if)#switchport trunk native vlan 510	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe6	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 6,511	Configure allowed VLANs

(config-if)#switchport trunk native vlan 511	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe7	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 7,512	Configure allowed VLANs
(config-if)#switchport trunk native vlan 512	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe9	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 9,513	Configure allowed VLANs
(config-if)#switchport trunk native vlan 513	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe10	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 10,514	Configure allowed VLANs
(config-if)#switchport trunk native vlan 514	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe11	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 11,515	Configure allowed VLANs
(config-if)#switchport trunk native vlan 515	Configure native VLAN.
(config-if)#load-interval 30	Set load interval

(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe12	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 12,516	Configure allowed VLANs
(config-if)#switchport trunk native vlan 516	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe13	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 13,517	Configure allowed VLANs
(config-if)#switchport trunk native vlan 517	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe14	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 14,518	Configure allowed VLANs
(config-if)#switchport trunk native vlan 518	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#commit	Commit the transaction.

OSPF configurations

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 46.46.46.46	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.10.21.0/24 area 0	Define the network on which OSPF runs and associate the area ID

(config-router)#network 10.10.22.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.23.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.24.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.25.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.26.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.27.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.28.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.29.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.30.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.31.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.32.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 46.46.46.46/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router) #commit	Commit the transaction.

PE2 Bridge Configuration

```
bridge 1 protocol ieee vlan-bridge
no bridge 1 spanning-tree enable bridge-forward
```

PE2 VLAN Creation

```
vlan database
vlan 9-14 bridge 1 state enable
vlan 519-524 bridge 1 state enable
```

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 49.49.49.49/32 secondary	Set the secondary IP address for the lo interface
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enable RSVP globally.
(config-router)#exit	Exit RSVP mode.
(config)#interface vlan1.9	Enter the interface mode.
(config-if)#ip address 10.10.21.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.

(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.10	Enter the interface mode.
(config-if)#ip address 10.10.22.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.11	Enter the interface mode.
(config-if)#ip address 10.10.29.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.12	Enter the interface mode.
(config-if)#ip address 10.10.30.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.13	Enter the interface mode.
(config-if)#ip address 10.10.31.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.14	Enter the interface mode.
(config-if)#ip address 10.10.32.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface xe9	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk

(config-if)#switchport trunk allowed vlan add 9,519	Configure allowed VLANs
(config-if)#switchport trunk native vlan 519	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe10	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 10,520	Configure allowed VLANs
(config-if)#switchport trunk native vlan 520	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe11	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 11,521	Configure allowed VLANs
(config-if)#switchport trunk native vlan 521	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe12	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 12,522	Configure allowed VLANs
(config-if)#switchport trunk native vlan 522	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe13	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 13,523	Configure allowed VLANs

(config-if)#switchport trunk native vlan 523	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe14	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 14,524	Configure allowed VLANs
(config-if)#switchport trunk native vlan 524	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(conf)#rsvp-path sp1-r3-r1 mpls	Create RSVP path
(conf-path)#10.10.21.1 strict	Configure nexthop
(conf-path)#10.10.23.1 strict	Configure nexthop
(conf)#rsvp-path sp2-r3-r1 mpls	Create RSVP path
(conf-path)#10.10.22.1 strict	Configure nexthop
(conf-path)#10.10.24.1 strict	Configure nexthop
(conf)#rsvp-path sp2-r3-r1 mpls	Create RSVP path
(conf-path)#10.10.29.2 strict	Configure nexthop
(conf-path)#10.10.25.1 strict	Configure nexthop
(conf)#rsvp-path sp3-r3-r1 mpls	Create RSVP path
(conf-path)#10.10.30.1 strict	Configure nexthop
(conf-path)#10.10.26.1 strict	Configure nexthop
(conf)#rsvp-path sp4-r3-r1 mpls	Create RSVP path
(conf-path)#10.10.31.1 strict	Configure nexthop
(conf-path)#10.10.27.1 strict	Configure nexthop
(conf)#rsvp-path sp5-r3-r1 mpls	Create RSVP path
(conf-path)#10.10.32.1 strict	Configure nexthop
(conf-path)#10.10.28.1 strict	Configure nexthop
(conf)#rsvp-trunk 49-47-test ipv4	Create a RSVP trunk link
(conf-trunk)#primary path p1-r3-r1	Configure primary path for trunk link
(conf-trunk)#secondary-priority 1 path sp1-r3-r1	Configure secondary link for trunk link
(conf-trunk)#secondary-priority 2 path sp2-r3-r1	Configure secondary link for trunk link
(conf-trunk)#secondary-priority 3 path sp3-r3-r1	Configure secondary link for trunk link
(conf-trunk)#secondary-priority 4 path sp4-r3-r1	Configure secondary link for trunk link

(conf-trunk)#secondary-priority 5 path sp5-r3-r1	Configure secondary link for trunk link
(conf-trunk)#to 47.47.47.47	Configure remote node for the LSP
(conf-trunk)#commit	Commit the transaction.

OSPF configurations

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 49.49.49.49	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.10.21.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.22.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.29.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.30.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.31.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.32.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 49.49.49.49/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router) #commit	Commit the transaction.

Validation

This example shows the number of configured RSVP sessions in a router.

PE2

```
#show rsvp session
```

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass

State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary

* indicates the session is active with local repair at one or more nodes

(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:

To Style	Labelin Label	From Labelout	Type DSType	LSPName	State	Uptime	Rt
47.47.47.47 1 1 SE	-	49.49.49.49 24970	PRI DEFAULT	49-47-test-Primary	UP	00:34:57	
47.47.47.47 1 1 SE	-	49.49.49.49 24968	SEC DEFAULT	49-47-test-Secondary-Priority-1	UP	00:34:56	

Total 2 displayed, Up 2, Down 0.

Egress RSVP:

To	From	Type	LSPName	State	Uptime	Rt
Style	Labelin	Labelout	DSType			
49.49.49.49	47.47.47.47	PRI	47-49-test-Primary	UP	00:34:45	
1 1 SE	31364 -	ELSP_CON				
49.49.49.49	47.47.47.47	PRI	47-49-test-Secondary-Priority-1	UP	00:34:44	
1 1 SE	31360 -	ELSP_CON				

Total 2 displayed, Up 2, Down 0.

```
#show rsvp trunk multi-sec-detail
Ingress (Secondary-Priority1)
47.47.47.47
  From: 49.49.49.49, LSPstate: Up, LSPname: 49-47-test-Secondary-Priority-1
  Ingress FSM state: Operational
  Establishment Time: 1s 71ms
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
  IGP-Shortcut: Disabled, LSP metric: 3
  LSP Protection: None
  Label in: -, Label out: 24968,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2214, Ext-Tunnel Id: 49.49.49.49
  Downstream: 45.49.24.1, vlan1.1024
  Path refresh: 30 seconds (RR enabled) (due in 27829 seconds)
  Resv lifetime: 157 seconds (due in 145 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: SP1-49-47 (in use)
  Configured Explicit Route Detail :
    45.49.24.1/32 strict
    46.45.9.1/32 strict
    47.46.3.1/32 strict
  Session Explicit Route Detail :
    45.49.24.1/32 strict
    46.45.9.1/32 strict
    47.46.3.1/32 strict
  Record route:
    -----
    IP Address      Label
    -----
    <self>
    45.49.24.1
    46.45.9.1
    47.46.3.1
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 9216
```

Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
Ingress (Secondary-Priority2)
47.47.47.47
From: 49.49.49.49, LSPstate: Dn, LSPname: 49-47-test-Secondary-Priority-2
Ingress FSM state: Idle
Setup priority: 7, Hold priority: 0
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
IGP-Shortcut: Disabled, LSP metric: 3
LSP Protection: None
Label in: -, Label out: -,
Tspec rate: 0, Fspec rate: 0
Policer: Not Configured
Tunnel Id: 5001, LSP Id: 2215, Ext-Tunnel Id: 49.49.49.49
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
Ingress (Secondary-Priority3)
47.47.47.47
From: 49.49.49.49, LSPstate: Dn, LSPname: 49-47-test-Secondary-Priority-3
Ingress FSM state: Idle
Setup priority: 7, Hold priority: 0
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: -, Label out: -,
Tspec rate: 0, Fspec rate: 0
Policer: Not Configured
Tunnel Id: 5001, LSP Id: 2213, Ext-Tunnel Id: 49.49.49.49
Last Recorded Error Code: Routing Problem (24)
Last Recorded Error Value: No route available toward destination (5)
Node where Last Recorded Error originated: None
Trunk Type: mpls
Ingress (Secondary-Priority4)
47.47.47.47
From: 49.49.49.49, LSPstate: Dn, LSPname: 49-47-test-Secondary-Priority-4
Ingress FSM state: Idle
Setup priority: 7, Hold priority: 0
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: -, Label out: -,
Tspec rate: 0, Fspec rate: 0
Policer: Not Configured

```
Tunnel Id: 5001, LSP Id: 2213, Ext-Tunnel Id: 49.49.49.49
Last Recorded Error Code: Routing Problem (24)
Last Recorded Error Value: No route available toward destination (5)
Node where Last Recorded Error originated: None
Trunk Type: mpls
Ingress (Secondary-Priority5)
47.47.47.47
  From: 49.49.49.49, LSPstate: Dn, LSPname: 49-47-test-Secondary-Priority-5
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -, Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
Tunnel Id: 5001, LSP Id: 2213, Ext-Tunnel Id: 49.49.49.49
Last Recorded Error Code: Routing Problem (24)
Last Recorded Error Value: No route available toward destination (5)
Node where Last Recorded Error originated: None
Trunk Type: mpls
```

Add Administrative Group Constraints to an LSP

To add administrative group constraints (also known as color constraints) to an LSP:

- Configure support for required administrative groups in NSM on all participating routers
- Configure required administrative groups on all participating interfaces

The configuration in this example forces the primary LSP to be setup through links that belong either to administrative group A or C. A link that does not belong to either of these administrative groups will not be used for setting up the LSP.

Note: This example is based on the assumption that a minimal configuration exists on all participating routers as described in [Enable Label Switching - Minimal Configuration](#).

PE1 - NSM

#configure terminal	Enter configure mode.
(config)#admin-group A 0	Add new administrative groups, specify their names and assign bit values to them.
(config)#admin-group B 1	
(config)#admin-group C 2	
(config)#admin-group D 3	
(config)#admin-group E 4	
(config)#interface xe0	Enter interface mode.
(config-if)#admin-group A	Add administrative groups to the links. When used in the interface mode, this command adds a link between an interface and a group. The name is the name of the group previously configured. You can have multiple groups per interface.
(config-if)#admin-group B	
(config-if)#admin-group C	

<code>(config-if)#exit</code>	Exit interface mode.
<code>(config)#interface xe2</code>	Enter interface mode.
<code>(config-if)#admin-group E</code>	Add administrative groups to the links. When used in the interface mode, this command adds a link between an interface and a group. The name is the name of the group previously configured. You can have multiple groups per interface.
<code>(config-if)#admin-group D</code>	
<code>(config-if)#commit</code>	Commit the transaction.

P - NSM

<code>#configure terminal</code>	Enter configure mode.
<code>(config)#admin-group A 0</code>	Add new administrative groups and specify their names and assign bit values to them.
<code>(config)#admin-group C 2</code>	
<code>(config)#interface xe2</code>	Enter interface mode
<code>(config-if)#admin-group A</code>	Add administrative groups to the links. When used in the interface mode, this command adds a link between an interface and a group. The name is the name of the group previously configured. You can have multiple groups per interface.
<code>(config-if)#admin-group C</code>	
<code>(config-if)#commit</code>	Commit the transaction.

PE1 - RSVP-TE

<code>(config)#router rsvp</code>	Enter the router mode for RSVP.
<code>(config-router)#rsvp-path P1</code>	Configure RSVP path.
<code>#configure terminal</code>	Enter configure mode.
<code>(config)#rsvp-trunk T1</code>	Create an RSVP trunk T1 and enter the Trunk mode.
<code>(config-trunk)#no primary cspf</code>	Since CSPF is enabled by default, specify <code>no primary cspf</code> if CSPF is not required.
<code>(config-trunk)#primary path P1</code>	Specify an RSVP primary path to be used.
<code>(config-trunk)#no primary cspf</code>	Specify the <code>no primary cspf</code> option for the LSP.
<code>(config-trunk)#primary include-any A</code>	Set up the LSP with admin group constraint A.
<code>(config-trunk)#primary include-any C</code>	Set up the LSP with admin group constraint C.
<code>(config-trunk)#to 192.168.0.90</code>	Specify the IPv4 egress (destination point) for the LSP.
<code>(config-trunk)#commit</code>	Commit the transaction.

Configure Global Parameters

Some common parameters can be configured in the Router mode on the RSVP-TE daemon. These parameters are global and affect all LSPs. In the following example the interval between two consecutive hello messages is set. The neighbor is defined by the `neighbor` command. Hello exchanges are enabled only between explicitly configured neighbors (configure this router as a neighbor on P (IP address 10.10.23.60)).

Note: This example is based on the assumption that a minimal configuration exists on all participating routers as described in [Enable Label Switching - Minimal Configuration](#).

PE1 - RSVP-TE

#configure terminal	Enter configure mode.
(config)#router rsvp	Enter the router mode for RSVP.
(config-router)#hello-interval 10	Set the hello-interval (in seconds) between hello packets.
(config-router)#hello-timeout 35	Set the hello-timeout value. If an LSR has not received a Hello message from a peer within this period, all sessions shared with this peer are reset.
(config-router)#neighbor 10.10.23.60	Explicitly specify the neighbor to exchange Hello messages with.
(config-router)#commit	Commit the transaction.

P - RSVP-TE

#configure terminal	Enter configure mode.
(config)#router rsvp	Enter the router mode for RSVP.
(config-router)#hello-interval 10	Set the hello-interval (in seconds) between hello packets.
(config-router)#hello-timeout 35	Set the hello-timeout value. If an LSR has not received a Hello message from a peer within this period, all sessions shared with this peer are reset.
(config-router)#neighbor 10.10.23.63	Explicitly specify the neighbor to exchange Hello messages with.
(config-router)#commit	Commit the transaction.

Fast Reroute Configuration (one-to-one method)

The Fast Reroute (FRR) configuration is a MPLS resiliency technology that provides fast traffic recovery when there is a link or router failure on mission critical services. These mechanisms enable the re-direction of traffic onto backup LSP tunnels in tens of milliseconds, in the event of a failure. The one-to-one backup method creates detour LSPs for each protected LSP at each potential point of local repair. This method is used to protect links and nodes during network failure.

In the below configurations each FRR trunk is mapped to VPWS,VPLS, and L3 VPN services.So it includes configurations of VPWS,VPLS and L3 VPN also.

[Figure 1-17](#) is a simple topology example for FRR:

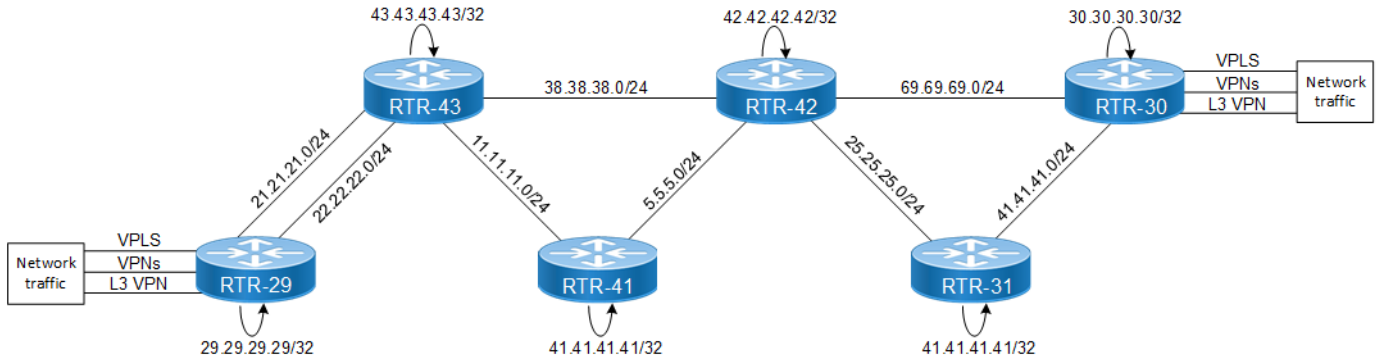


Figure 1-17: Topology Example for Fast Reroute

RTR-29

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 29.29.29.29/32 secondary	Set a secondary IP address of the interface
(config-if)#no shutdown	Administratively bring the interface up.
(config-if)#exit	Exit interface mode.
(config)#router-id 29.29.29.29	Configure the router ID.
(config)#router rsvp	Enter to router rsvp mode.
(config-router)#exit	Exit the router mode
(config)#router ldp	Enter to router LDP mode.
(config-router)#targeted-peer ipv4 30.30.30.30	Configure targeted peer.
(config-router-targeted-peer)#exit-targeted- peer-mode	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#interface xe21	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 21.21.21.29/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#enable-ldp ipv4	Enable LDP on this interface
(config-if)#exit	Exit interface mode.
(config)#interface xe22	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface
(config-if)#enable-ldp ipv4	Enable LDP on this interface
(config-if)#ip address 22.22.22.29/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf	Enter the router configure mode for OSPF.

(config-router)#router-id 29.29.29.29	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 21.21.21.0/24 area 0 (config-router)#network 22.22.22.0/24 area 0 (config-router)#network 29.29.29.29/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#exit	Exit the router configure mode.
(config)#rsvp-path p21	Enter the path mode for RSVP pt1.
(config-path)#21.21.21.43 strict	Configure this explicit route path as a strict hop.
(config-path)#38.38.38.42 strict	Configure this explicit route path as a strict hop.
(config-path)#69.69.69.30 strict	Configure this explicit route path as a strict hop.
(config)#exit	Exit the path mode.
(config)#rsvp-trunk to_30 ipv4	Enter the trunk mode for RSVP.
(config-trunk)#primary fast-reroute protection one-to-one	Configure primary fast-reroute protection facility for a trunk.
(config-trunk)#primary fast-reroute node-protection	Configure primary fast-reroute node protection for the trunk
(config-trunk)#primary path p21	Configure trunk to 30 to use the defined path.
(config-trunk)#to 30.30.30.30	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#exit	Exit from trunk mode.
(config)#ip vrf vrf1	Configure VRF instance
(config-vrf)#rd 100:1	Configure Router Distinguisher value
(config-vrf)#route-target both 100:1	Configure route-target as both
(config-vrf)#exit	Exit the path mode.
(config)#interface xe43	Enter to the interface mode
(config-if)#ip vrf forwarding vrf1	Bind the VRF instance to the interface
(config-if)#ip address 43.43.43.29/24	Configure IP address
(config-if)#exit	Exit interface mode.
(config)#router bgp 100	Configure BGP router instance
(config-router)#neighbor 30.30.30.30 remote-as 100	Configure neighbor with remote-as
(config-router)#neighbor 30.30.30.30 update-source 29.29.29.29	Configure update source as loopback address
(config-router)#address-family vpnv4 unicast	Configure VPNv4 address family
(config-router-af)#neighbor 30.30.30.30 activate	Activate the VPN neighbor
(config-router-af)#exit-address-family	Exit the VPN address family
(config-router)#address-family ipv4 vrf vrf1	Configure VRF address family
(config-router-af) redistribute connected	Redistribute connected route
(config-router-af) exit-address-family	Exit VRF address family
(config-router)#exit	Exit router mode
(config)#mpls l2-circuit vlan10 10 30.30.30.30	Configure Virtual circuit.
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#service-template st1	Template configuration

(config-svc)#match outer-vlan 10	Match criteria under template configuration
(config-svc)#exit	Exit service template mode
(config)#service-template st2	Template configuration
(config-svc)#match outer-vlan 30	Match criteria under template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe44	Enter interface configuration mode
(config-if)#switchport	Configure interface as switch port
(config-if)#mpls-l2-circuit t1 service-template st1	Bind the interface to the VC with service template
(config-if)#exit	Exit interface configuration mode
(config)#mpls vpls vpls30 30	Configure VPLS instance
(config-vpls)#signaling ldp	Configure VPLS signaling as LDP
(config-vpls-sig)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 30.30.30.30	Configure VPLS peer
(config-vpls-sig)#exit-signaling	Exit VPLS configuration mode
(config)#interface xe45	Enter interface configuration mode
(config-if)#switchport	Configure interface as switch port
(config-if)#mpls-vpls vpls30 service-template st2	Bind the VPLS instance to the interface
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#commit	Commit the transaction.

RTR-43

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 43.43.43.43/32 secondary	Set a secondary IP address of the interface
(config-if)#no shutdown	Administratively shutdown the interface.
(config-if)#exit	Exit interface mode.
(config)#router-id 43.43.43.43	Configure the router ID.
(config)#router rsvp	Enter to router RSVP mode.
(config-router)#exit	Exit the router mode
(config)#interface xe5/1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 11.11.11.43/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe9/1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface

(config-if)#ip address 21.21.21.43/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe9/2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 22.22.22.43/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe13/2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface
(config-if)#ip address 38.38.38.43/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf	Enter the router configure mode for OSPF.
(config-router)#router-id 43.43.43.43	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 11.11.11.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 22.22.22.0/24 area 0	
(config-router)#network 21.21.21.0/24 area 0	
(config-router)#network 38.38.38.0/24 area 0	
(config-router)#network 43.43.43.43/32 area 0	
(config-router)#commit	Commit the transaction.

RTR-42

(config)#interface lo	Enter interface mode.
(config-if)#ip address 42.42.42.42/32 secondary	Set a secondary IP address of the interface
(config-if)#no shutdown	Administratively shutdown the interface.
(config-if)#exit	Exit interface mode.
(config)#router-id 42.42.42.42	Configure the router ID.
(config)#router rsvp	Enter to router RSVP mode.
(config-router)#exit	Exit the router mode
(config)#interface xe2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 5.5.5.42/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe10/1	Enter interface mode.

(config-if)#label-switching	Enable label switching on interface
(config-if)#ip address 25.25.25.42/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 38.38.38.42/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe4	Enter interface mode
(config-if)#label-switching	Enable label switching on interface
(config-if)#ip address 69.69.69.42/24	Specify an IP address for the interface
(config-if)#no shutdown	Administratively no shutdown the interface
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface
(config-if)#exit	Exit interface mode
(config)#router ospf	Enter the router configure mode for OSPF.
(config-router)#router-id 42.42.42.42	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 5.5.5.0/24 area 0 (config-router)#network 25.25.25.0/24 area 0 (config-router)#network 69.69.69.0/24 area 0 (config-router)#network 38.38.38.0/24 area 0 (config-router)#network 42.42.42.42/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#commit	Commit the transaction

RTR-41

(config)#interface lo	Enter interface mode.
(config-if)#ip address 44.44.44.44/32 secondary	Set a secondary IP address of the interface
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#exit	Exit interface mode.
(config)#router-id 44.44.44.44	Configure the router ID.
(config)#router rsvp	Enter to router RSVP mode.
(config-router)#exit	Exit the router mode
(config)#interface xel1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 1.1.1.41/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.

(config)#interface xe2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface
(config-if)#ip address 5.5.5.41/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe5/1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 11.11.11.41/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf	Enter the router configure mode for OSPF.
(config-router)#router-id 44.44.44.44	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 5.5.5.0/24 area 0 (config-router)#network 1.1.1.0/24 area 0 (config-router)#network 11.11.11.0/24 area 0 (config-router)#network 44.44.44.44/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#commit	Commit the transaction.

RTR-31

(config)#interface lo	Enter interface mode.
(config-if)#ip address 31.31.31.31/32 secondary	Set a secondary IP address of the interface
(config-if)#no shutdown	Administratively shutdown the interface.
(config-if)#exit	Exit interface mode.
(config)#router-id 31.31.31.31	Configure the router ID.
(config)#router rsvp	Enter to router RSVP mode.
(config-router)#exit	Exit the router mode
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 1.1.1.31/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe25	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface
(config-if)#ip address 25.25.25.31/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.

(config-if)#exit	Exit interface mode.
(config)#interface xe41	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 41.41.41.31/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf	Enter the router configure mode for OSPF.
(config-router)#router-id 31.31.31.31	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 1.1.1.0/24 area 0 (config-router)#network 25.25.25.0/24 area 0 (config-router)#network 41.41.41.0/24 area 0 (config-router)#network 31.31.31.31/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#commit	Commit the transaction.

RTR-30

(config)#interface lo	Enter interface mode.
(config-if)#ip address 30.30.30.30/32 secondary	Set a secondary IP address of the interface
(config-if)#no shutdown	Administratively shutdown the interface.
(config-if)#exit	Exit interface mode.
(config)#router-id 30.30.30.30	Configure the router ID.
(config)#router rsvp	Enter to router RSVP mode.
(config-router)#exit	Exit the router mode
(config)#router ldp	Enter to router LDP mode.
(config-router)#targeted-peer ipv4 29.29.29.29	Configure targeted peer.
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#interface xe41	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 41.41.41.30/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#enable-ldp ipv4	Enable LDP on this interface
(config-if)#exit	Exit interface mode.
(config)#interface xe54/1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface
(config-if)#enable-ldp ipv4	Enable LDP on this interface
(config-if)#ip address 69.69.69.30/24	Set an IP address of the interface.

(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf	Enter the router configure mode for OSPF.
(config-router)#router-id 30.30.30.30	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 41.41.41.0/24 area 0 (config-router)#network 69.69.69.0/24 area 0 (config-router)#network 30.30.30.30/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#commit	Commit the transaction.
(config)#rsvp-path p41	Enter the path mode for RSVP pt1.
(config-path)#41.41.41.31 strict	Configure this explicit route path as a strict hop.
(config-path)#1.1.1.41 strict	Configure this explicit route path as a strict hop.
(config-path)#11.11.11.43 strict	Configure this explicit route path as a strict hop.
(config)#exit	Exit the path mode.
(config)#rsvp-trunk to_29 ipv4	Enter the trunk mode for rsvp.
(config-trunk)#primary fast-reroute protection one-to-one	Configure primary fast-reroute protection facility for a trunk.
(config-trunk)#primary fast-reroute node-protection	Configure primary fast-reroute node protection for the trunk
(config-trunk)#primary path p41	Configure trunk to_29 to use the defined path.
(config-trunk)#to 29.29.29.29	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#exit	Exit from trunk mode.
(config)#ip vrf vrf1	Configure VRF instance
(config-vrf)#rd 100:1	Configure Router Distinguisher value
(config-vrf)#route-target both 100:1	Configure route-target as both
(config-vrf)#exit	Exit the path mode.
(config)#interface xe23	Enter to the interface mode
(config-if)#ip vrf forwarding vrf1	Bind the VRF instance to the interface
(config-if)#ip address 23.23.23.29/24	Configure IP address
(config-if)#exit	Exit interface mode.
(config)#router bgp 100	Configure BGP router instance
(config-router)#neighbor 29.29.29.29 remote-as 100	Configure neighbor with remote-as
(config-router)#neighbor 29.29.29.29 update-source 30.30.30.30	Configure update source as loopback address
(config-router)#address-family vpnv4 unicast	Configure VPNv4 address family
(config-router-af)#neighbor 29.29.29.29 activate	Activate the VPN neighbor
(config-router-af)#exit-address-family	Exit the VPN address family
(config-router)#address-family ipv4 vrf vrf1	Configure VRF address family
(config-router-af) redistribute connected	Redistribute connected route
(config-router-af) exit-address-family	Exit VRF address family

(config-router)#exit	Exit router mode
(config)#mpls l2-circuit vlan10 10 29.29.29.29	Configure Virtual circuit.
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#service-template st1	Template configuration
(config-svc)#match outer-vlan 10	Match criteria under template configuration
(config-svc)#exit	Exit service template mode
(config)#service-template st2	Template configuration
(config-svc)#match outer-vlan 30	Match criteria under template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe24	Enter interface configuration mode
(config-if)#switchport	Configure interface as switch port
(config-if)#mpls-l2-circuit vlan10 service-template st1	Bind the interface to the VC with service template
(config-if)#exit	Exit interface configuration mode
(config)#mpls vpls vpls30 30	Configure VPLS instance
(config-vpls)#signaling ldp	Configure VPLS signaling as LDP
(config-vpls-sig)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 29.29.29.29	Configure VPLS peer
(config-vpls-sig)#exit-signaling	Exit VPLS configuration mode
(config)#interface xe25	Enter interface configuration mode
(config-if)#switchport	Configure interface as switch port
(config-if)#mpls-vpls vpls30 service-template st2	Bind the VPLS instance to the interface
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#commit	Commit the transaction.

Validation

RTR-30#show rsvp session

Ingress RSVP:

To	From	State	Uptime	Pri	Rt	Style	Labelin
Labelout	LSPName		Est.time			D	
29.29.29.29	30.30.30.30	Up	00:07:53	Yes	1 1	SE	-
24322	to_29-Primary		0s	118ms		D	
EFAULT							
29.29.29.29	69.69.69.30	Up	00:07:53	No	1 1	SE	-
24322	to_29-Detour		0s	4ms		DEF	
AULT							

Total 2 displayed, Up 2, Down 0.

Egress RSVP:

To	From	State	Uptime	Pri	Rt	Style	Labelin
Labelout	LSPName		Est.time			D	


```
30.30.30.30      29.29.29.29      Up
to_30-Primary    00:07:57 N/A      Yes 1 1 SE      24960  -
CON
30.30.30.30      25.25.25.42      Up
to_30-Detour     00:07:57 N/A      Yes 1 1 SE      24961  -
CON
Total 2 displayed, Up 2, Down 0.
```

```
RTR-30#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
```

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-
Label	Out-Intf	Nextthop				
R(t)>	29.29.29.29/32	1	5001	Yes	LSP_DEFAULT	24322
xe2	41.41.41.31					
R(t)>	29.29.29.29/32	2	5001	No	LSP_DEFAULT	24322
xe1	69.69.69.42					

RTR-30#

```
RTR-30#show mpls vrf-table
Output for IPv4 VRF table with id: 2
Primary FTN entry with FEC: 43.43.43.0/24, id: 1, row status: Active
Owner: BGP, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 5001, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 6
Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: BGP, out intf: xe1, out label: 25602
Nextthop addr: 29.29.29.29 cross connect ix: 7, op code: Push and
Lookup
```

Link 41.41.41.0/24 Goes down. Interface xe41 on router 30 is administratively disabled with the "shutdown command".

RTR-30#

```
RTR-30#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
RTR-30(config)#int xe41
RTR-30(config-if)#shutdown
RTR-30(config-if)#
```

```
RTR-30#show rsvp session
Ingress RSVP:
To          From          State          Pri Rt  Style Labelin
Labelout LSPName          Uptime        Est.time      D
SType
29.29.29.29 30.30.30.30 Using Backup   Yes 0 0 SE    -    -
to_29-Primary N/A   DEFAULT
29.29.29.29 30.30.30.30 Dn            Yes 0 0 SE    -    -
to_29-Primary N/A   DEFAULT
```

```
29.29.29.29      69.69.69.30      Up      No 1 1 SE      -
24322      to_29-Detour      00:10:53 0s 4ms DEF
AULT
Total 3 displayed, Up 1, Down 2.
```

Egress RSVP:

```
To      From      State      Pri Rt      Style Labelin
Labelout LSPName      Uptime      Est.time      D
SType
30.30.30.30      29.29.29.29      Up      Yes 1 1 SE      24960      -
to_30-Primary      00:10:57 N/A      ELSP
_CON
Total 1 displayed, Up 1, Down 0.
```

RTR-30#show mpls vc-table

```
VC-ID      Vlan-ID      Inner-Vlan-ID      Access-Intf      Network-Intf      Out Label
Tunnel-Label      Nexthop      Status
10      N/A      N/A      xe4      xe1      24321      24322
29.29.29.29      Active
RTR-30#
```

RTR-30#show mpls vpls mesh

```
VPLS-ID      Peer Addr      Tunnel-Label      In-Label      Network-Intf      Out-Label
Lkps/St      PW-INDEX      SIG-Protocol      Status
30      29.29.29.29      24322      24320      xe41      24320
2/Up      2      LDP      Active
```

Link 41.41.41.0/24 is reestablished. Interface xe41 is administratively re-enabled.

RTR-30#configure terminal

Enter configuration commands, one per line. End with CNTL/Z.

```
RTR-30(config)#int xe41
RTR-30(config-if)#no shutdown
RTR-30(config-if)#
RTR-30#
```

RTR-30#show rsvp session

Ingress RSVP:

```
To      From      State      Pri Rt      Style Labelin
Labelout LSPName      Uptime      Est.time      D
SType
29.29.29.29      30.30.30.30      Up      Yes 1 1 SE      -
24322      to_29-Primary      00:00:01 0s 8ms DEF
AULT
29.29.29.29      69.69.69.30      Up      No 1 1 SE      -
24322      to_29-Detour      00:00:01 0s 8ms DEF
AULT
Total 2 displayed, Up 2, Down 0.
```

Egress RSVP:

```
To      From      State      Pri Rt      Style Labelin
Labelout LSPName      Uptime      Est.time      D
```

```

SType
30.30.30.30      29.29.29.29      Up      Yes 1 1 SE      24960      -
to_30-Primary    00:13:22 N/A      ELSP
CON
30.30.30.30      25.25.25.42      Up      Yes 1 1 SE      24961      -
to_30-Detour     00:00:08 N/A      ELSP
CON
Total 2 displayed, Up 2, Down 0.

```

```

RTR-30#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
        B - BGP FTN, K - CLI FTN, t - tunnel
        L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
        U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

```

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-
Label	Out-Intf	Nextthop				
R(t)>	29.29.29.29/32	1	5001	Yes	LSP_DEFAULT	24322
xe41	41.41.41.31					
R(t)>	29.29.29.29/32	2	5001	No	LSP_DEFAULT	24322
xe54/1	69.69.69.42					

Note: The primary LSP, which is in using backup state shall continue to use backup path in case where secondary is provisioned after the LSP state is changed to switch to backup.

MPLS RSVP PING and TRACEROUTE

This example shows MPLS ping and trace route for RSVP

```

#ping mpls rsvp tunnel-name to_30 detail
Sending 5 MPLS Echos to to_30, timeout is 5 seconds
Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
Type 'Ctrl+C' to abort
! seq_num = 1 30.30.30.30 0.28 ms
! seq_num = 2 30.30.30.30 0.24 ms
! seq_num = 3 30.30.30.30 0.22 ms
! seq_num = 4 30.30.30.30 0.22 ms
! seq_num = 5 30.30.30.30 0.22 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.22/0.25/0.28

RTR-29#trace mpls rsvp tunnel-name to_30 detail
Tracing MPLS Label Switched Path to to_30, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,

```

'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
 'N' - LBL Mapping Err, 'D' - DS Mismatch,
 'U' - Unknown Interface, 'R' - Transit (LBL Switched),
 'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
 'P' - Protocol Error, 'X' - Unknown code,
 'Z' - Reverse FEC Validation Failed

Type 'Ctrl+C' to abort

```
0 21.21.21.29 [Labels: 24320]
R 1 43.43.43.43 [Labels: 24320] 123.22 ms
R 2 42.42.42.42 [Labels: 24960] 1.60 ms
! 3 30.30.30.30 1.62 ms
```

MPLS RSVP Entropy Label Capabilities

To share the load across multiple members of a LAG port in the core of an MPLS network we can use entropy labels

An Entropy Label is always preceded by an Entropy level indicator which is a special Label with value seven, and indicates the next label present is an Entropy label. The trade off is the MPLS stack depth increases by two and it reduces overhead on transit routers.

Note: Load balancing is enabled by default for all the parameters. If you enable load balancing manually, then all the parameters enabled by default are reset and you need to enable the parameters based on which traffic should be load balanced.

Entropy labels will only be added when the remote edge node advertises its capability for Entropy.

The examples below show how entropy can be enabled on a provider edge node as per the setup we need to enable on RTR29 and RTR30 to have entropy enabled in both directions:

```
(config)#router rsdp
(config-router)#entropy-label-capability
```

This enables ELC signaling for RSVP.

For validation, use:

```
#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, B - BGP FTN, K - CLI FTN, t -
tunnel
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
```

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-Label	ELC	Out-Intf	Nexthop
R(t)>	2 9.29.29.29/32	1	5001	Yes	LSP_DEFAULT	24322	yes		
xe2	1.41.41.31								
R(t)>	29.29.29.29/32	2	5001	No	LSP_DEFAULT	4322	yes		
xe1	69.69.69.42								

```
#show rsdp session ingress detail
Ingress (Primary)
41.41.41.31
From: 29.29.29.29, LSPstate: Up, LSPname: t1-Primary
```

Ingress FSM state: Operational
Establishment Time: 0s 3ms
Setup priority: 7, Hold priority: 0
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
IGP-Shortcut: Disabled, LSP metric: 1
LSP Protection: None
Label in: -, Label out: 24320, ELC

MPLS RSVP LSP Re-optimization

Follow these steps to configure RSVP LSP Re-optimization.

#configure terminal	Enter configure mode.
(config)#rsvp-trunk T1	Create an RSVP trunk T1 and enter the Trunk mode.
(config-trunk)#reoptimize	Enable re-optimization of the session.
#configure terminal	Enter configure mode.
(config)#router rsvp	Enter RSVP mode
(config-router)#lsp-reoptimization-timer 5	Sets the re-optimization timer for the session.

Follow these steps to force the LSP to be re-optimized.

(config)#rsvp-trunk t1 force-reoptimize	Re-optimize the LSP forcefully
---	--------------------------------

CHAPTER 2 RSVP-TE Facility Backup (Facility Bypass)

RSVP supports multiple path protection mechanisms and facility backup is one of them. With facility backup protection, N number of LSPs sharing the common path can be protected using one bypass tunnel which leads to resource utilization.

Note: Do not configure a facility backup trunk with the same transit node as that of the primary trunk.

Topology

As shown in [Figure 2-18](#), we have four routers R1, R2, R3, and R4.

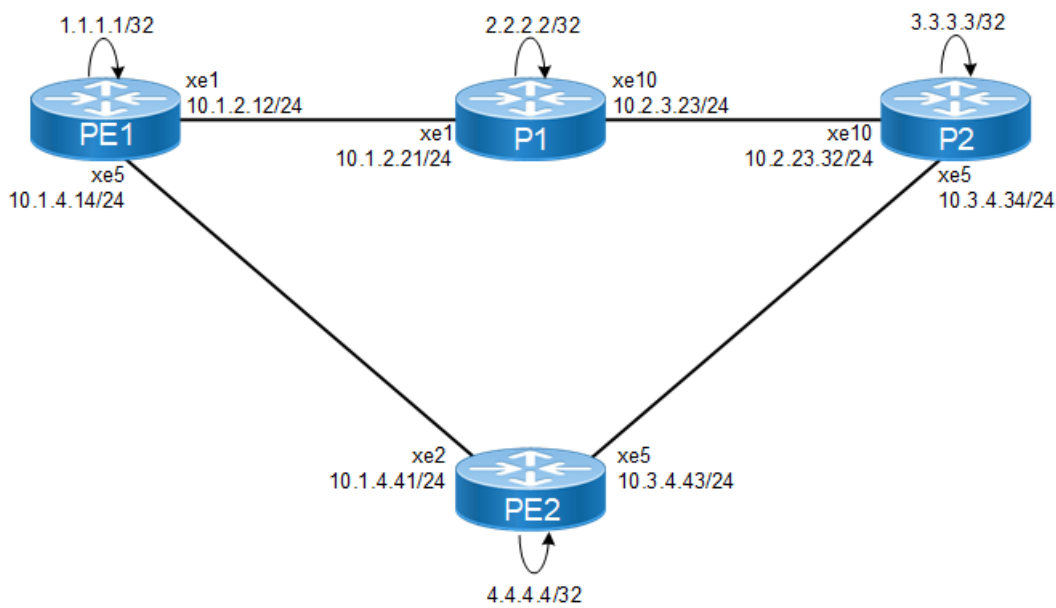


Figure 2-18: RSVP facility backup

Configuration

PE1

#configure terminal	Enter configuration mode
(config)#interface lo	Specify interface loopback for configuration
(config-if)#ip address 1.1.1.1/32 secondary	Configure ip address of loopback
(config-if)#exit	Exit interface configuration mode
(config)#interface xe1	Specify interface xe1 for configuration
(config-if)#ip address 10.1.2.12/24	Configure ip address of interface
(config)#exit	Exit interface configuration mode
(config-if)#int xe5	Specify interface xe1 for configuration
(config-if)#ip address 10.1.4.14/24	Configure ip address of loopback

(config-if)#exit	Exit configuration mode
(config)#router ospf 1	Configure the router OSPF with process id
(config-router)#router-id 1.1.1.1	Configure OSPF router-id
(config-router)#network 1.1.1.1/32 area 1	Define the network of the interface with area 0
(config-router)#network 10.1.2.0/24 area 1	Define the network of the interface with area 0
(config-router)#network 10.1.4.0/24 area 1	Define the network of the interface with area 0
(config-router)#exit	Exit the configure mode
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#exit	Exit the configure mode
(config)#router ospf 1	Enter router OSPF mode with process id
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)#exit	Exit the router mode
(config)#router rsvp	Enter router RSVP
(config-router)#exit	Exit the router configuration mode
(config)#interface xe1	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#exit	Exit the interface configuration mode
(config)#interface xe5	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#commit	Commit the transaction.

P1

(config)#interface lo	Specify the interface (lo)
(config-if)#ip address 2.2.2.2/32 secondary	Enter the loopback ip address as secondary
(config-if)#exit	Exit the interface configure mode
(config-if)#int xe1	Specify the interface(xe1)
(config-if)#ip address 10.1.2.21/24	Configure the IP address for the interface
(config-if)#exit	Exit the interface mode
(config-if)#int xe10	Specify the interface(xe1)
(config-if)#ip address 10.2.3.23/24	Configure the IP address for the interface
(config-if)#exit	Exit the configuration mode
(config)#router ospf 1	Configure OSPF router-id
(config-router)#router-id 2.2.2.2	Configure the router id
(config-router)#network 2.2.2.2/32 area 1	Define the network of the interface with area 0
(config-router)#network 10.1.2.0/24 area 1	Define the network of the interface with area 0
(config-router)#network 10.2.3.0/24 area 1	Define the network of the interface with area 0
(config-router)#exit	Exit the configure mode
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval

(config)#exit	Exit the configure mode
(config)#router ospf 1	Enter router OSPF mode with process id
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)#exit	Exit the router mode
(config)#router rsvp	Enter router RSVP
(config-router)#exit	Exit the router configuration mode
(config)#interface xe1	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#exit	Exit the interface configuration mode
(config)#interface xe10	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#commit	Commit the transaction.

P2

(config)#interface lo	Specify the interface (lo)
(config-if)#ip address 3.3.3.3/32 secondary	Enter the loopback ip address as secondary
(config-if)#exit	Exit the interface configuration mode
(config-if)#int xe10	Specify the interface(xe1)
(config-if)#ip address 10.2.3.32/24	Configure the IP address for the interface
(config-if)#exit	Exit the interface mode
(config-if)#interface xe5	Specify the interface(xe1)
(config-if)#ip address 10.3.4.34/24	Configure the IP address for the interface
(config-if)#exit	Exit the configuration mode
(config)#router ospf 1	Configure OSPF router-id
(config-router)#router-id 3.3.3.3	Configure the router id
(config-router)#network 3.3.3.3/32 area 1	Define the network of the interface with area 0
(config-router)#network 10.3.4.0/24 area 1	Define the network of the interface with area 0
(config-router)#network 10.2.3.0/24 area 1	Define the network of the interface with area 0
(config-router)#exit	Exit the configure mode
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#exit	Exit the configure mode
(config)#router ospf 1	Enter router OSPF mode with process id
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)#exit	Exit the router mode
(config)#router rsvp	Enter router RSVP
(config-router)#exit	Exit the router configuration mode
(config)#interface xe10	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP

(config-if)#label-switching	Enable label-switching
(config-if)#exit	Exit the interface configuration mode
(config)#interface xe5	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#commit	Commit the transaction.

PE2

(config)#interface lo	Specify the interface (lo)
(config-if)#ip address 4.4.4.4/32 secondary	Enter the loopback IP address as secondary
(config-if)#exit	Exit the interface configuration mode
(config-if)#interface xe2	Specify the interface(xe1)
(config-if)#ip address 10.1.4.41/24	Configure the ip address for the interface
(config-if)#exit	Exit the interface mode
(config-if)#int xe5	Specify the interface(xe1)
(config-if)#ip address 10.3.4.43/24	Configure the ip address for the interface
(config-if)#exit	Exit the configuration mode
(config)#router ospf 1	Configure ospf router-id
(config-router)#router-id 4.4.4.4	Configure the router id
(config-router)#network 4.4.4.4/32 area 1	Define the network of the interface with area 0
(config-router)#network 10.1.4.0/24 area 1	Define the network of the interface with area 0
(config-router)#network 10.3.4.0/24 area 1	Define the network of the interface with area 0
(config-router)#exit	Exit the configure mode
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#exit	Exit the configuration mode
(config)#router ospf 1	Exit the router OSPF mode with process id
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)#exit	Exit the router mode
(config)#router rsvp	Enter router RSVP
(config-router)#exit	Exit the router configuration mode
(config)#interface xe1	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#exit	Exit the interface configuration mode
(config)#interface xe5	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#commit	Commit the transaction.

RSVP Path on PE1

(config)#rsvp-path primary_1	Enter the rsvp-path configuration mode with name
(config-path)#10.1.2.21 strict	Specify the first next-hop ip address
(config-path)#10.2.3.32 strict	Specify the second next-hop ip address
(config-path)#exit	Exit the rsvp-path configuration mode
#configure terminal	Enter the configuration mode
(config)#rsvp-path bypass_1	Enter the rsvp-path configuration mode with name
(config-path)#10.1.4.41 strict	Specify the first next-hop ip address
(config-path)#10.3.4.34 strict	Specify the second next-hop ip address
(config-path)#exit	Exit the rsvp-path configuration mode
#configure terminal	Enter the configuration mode
(config)#rsvp-trunk R1-R3	Enter the rsvp trunk to be created with name
(config-trunk)#primary path primary_1	Configure primary path for the trunk
(config-trunk)#to 3.3.3.3	Enter the destination ip
(config-trunk)#primary fast-reroute protection facility	Configure facility backup protection for the trunk
(config-trunk)#exit	Exit the configuration mode
(config)#rsvp-bypass B1-B8	Enter the rsvp bypass to be created with name
(config-trunk)#path bypass_1	Configure primary path for the trunk
(config-trunk)#to 3.3.3.3	Enter the destination IP
(config-if)#commit	Commit the transaction.

Validation**OSPF Neighborhood****PE1**

```
#show ip ospf neighbor
```

```
Total number of full neighbors: 2
```

```
OSPF process 1 VRF(default):
```

Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
2.2.2.2 0	1	Full/Backup	00:00:38	10.1.2.21	xe1
4.4.4.4 0	1	Full/DR	00:00:33	10.1.4.41	xe5

P1

```
#show ip ospf neighbor
```

```
Total number of full neighbors: 2
```

```
OSPF process 1 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
-------------	-----	-------	-----------	---------	-----------	-------------

1.1.1.1	1	Full/DR	00:00:35	10.1.2.12	xe1	0
3.3.3.3	1	Full/Backup	00:00:34	10.2.3.32	xe10	0

P2

```
#show ip ospf neighbor
```

Total number of full neighbors: 2

OSPF process 1 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
2.2.2.2	1	Full/DR	00:00:37	10.2.3.23	xe10	0
4.4.4.4	1	Full/Backup	00:00:39	10.3.4.43	xe5	0

PE2

```
#show ip ospf neighbor
```

Total number of full neighbors: 2

OSPF process 1 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
1.1.1.1	1	Full/Backup	00:00:38	10.1.4.14	xe2	0
3.3.3.3	1	Full/DR	00:00:36	10.3.4.34	xe5	0

RSVP Session**PE1**

```
#show rsvp session
```

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass

State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary

* indicates the session is active with local repair at one or more nodes

Ingress RSVP:

To	From	Type	LSPName	State	Uptime	Rt
Style	Labelin	Labelout	DSType			
3.3.3.3	1.1.1.1	PRI	R1-R3-Primary	UP	00:54:48	1
1 SE	-	24321	DEFAULT			
3.3.3.3	1.1.1.1	BPS	B1-B4-Bypass	UP	01:08:32	1
1 SE	-	24321	DEFAULT			

Total 2 displayed, Up 2, Down 0.

```
#show rsvp bypass
```

Ingress RSVP:

To	From	LSPName	State	Uptime	Rt	Style
Labelin	Labelout	DSType				
3.3.3.3	1.1.1.1	B1-B4-Bypass	UP	01:09:17	1	1 SE
-	24321	DEFAULT				

```
#show rsvp bypass protected-lsp-list
```

Bypass trunk: B1-B4

Bypass trunk bandwidth type: best-effort

List of LSP's Protected:

Tunnel-id	Lsp Id	Lsp Name	Role	Ext_tnl_id	Ingress
Egress					

```
5001      2202      R1-R3-Primary      Ingress  1.1.1.1      1.1.1.1
3.3.3.3
Total LSP protected : 1
Bandwidth in use : 0
```

```
#show rsvp bypass B1-B4 protected-lsp-list
```

```
Bypass trunk: B1-B4
```

```
Bypass trunk bandwidth type: best-effort
```

```
List of LSP's Protected:
```

Tunnel-id	Lsp Id	Lsp Name	Role	Ext_tnl_id	Ingress
5001	2202	R1-R3-Primary	Ingress	1.1.1.1	1.1.1.1

```
3.3.3.3
```

```
Total LSP protected : 1
```

```
Bandwidth in use : 0
```

```
#show rsvp session detail
```

```
Ingress (Primary)
```

```
3.3.3.3
```

```
From: 1.1.1.1, LSPstate: Up, LSPname: R1-R3-Primary
```

```
Ingress FSM state: Operational
```

```
Establishment Time: 0s 8ms
```

```
Setup priority: 7, Hold priority: 0
```

```
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
```

```
IGP-Shortcut: Disabled, LSP metric: 2
```

```
LSP Protection: facility
```

```
Fast-Reroute bandwidth : 0
```

```
Protection type desired: Link
```

```
Fast-Reroute Setup priority: 7, Hold priority: 0
```

```
Bypass trunk: B1-B4, Merge Point: 10.2.3.32, MP Label: 3
```

```
    Bypass OutLabel: 24321, OutIntf: xe5
```

```
    Protection provided -> Type: Link, BW: Best-effort
```

```
Label in: -, Label out: 24321
```

```
Tspec rate: 0, Fspec rate: 0
```

```
Policer: Not Configured
```

```
Tunnel Id: 5001, LSP Id: 2202, Ext-Tunnel Id: 1.1.1.1
```

```
Downstream: 10.1.2.21, xe1
```

```
Path refresh: 30 seconds (RR enabled) (due in 26564 seconds)
```

```
Resv refresh: 0 seconds (due in 0 seconds)
```

```
Resv lifetime: 157 seconds (due in 150 seconds)
```

```
Retry count: 0, intrvl: 30 seconds
```

```
RRO re-use as ERO: Disabled
```

```
Label Recording: Enabled
```

```
Admin Groups: none
```

```
Configured Path: primary_1 (in use)
```

```
Configured Explicit Route Detail :
```

```
    10.1.2.21/32 strict
```

```
    10.2.3.32/32 strict
```

```
Session Explicit Route Detail :
```

```

10.1.2.21/32 strict
10.2.3.32/32 strict
Record route:
LP = 1 -> PLR's Downstream link is protected      PU = 1 -> Protection is in use on
PLR
NP = 1 -> PLR's Downstream neighbor is protected  BP = 1 -> BW protection available
at PLR

```

```

-----
IP Address      Label      (LP, PU, NP, BP)
-----

```

```

<self>

```

```

10.1.2.21      24321      ( 0,  0,  0,  0)

```

```

10.2.3.32      3        ( 0,  0,  0,  0)

```

```

Style: Shared Explicit Filter

```

```

Traffic type: controlled-load

```

```

Minimum Path MTU: 1500

```

```

Last Recorded Error Code: None

```

```

Last Recorded Error Value: None

```

```

Node where Last Recorded Error originated: None

```

```

Trunk Type: mpls

```

```

Ingress (Bypass)

```

```

3.3.3.3

```

```

From: 1.1.1.1, LSPstate: Up, LSPname: B1-B4-Bypass

```

```

Ingress FSM state: Operational

```

```

Establishment Time: 0s 14ms

```

```

Setup priority: 7, Hold priority: 0

```

```

CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds

```

```

IGP-Shortcut: Disabled, LSP metric: 2

```

```

LSP Protection: None

```

```

Bypass trunk bandwidth type: Best-effort

```

```

Label in: -, Label out: 24321

```

```

Tspec rate: 0, Fspec rate: 0

```

```

Policer: Not Configured

```

```

Tunnel Id: 5002, LSP Id: 2203, Ext-Tunnel Id: 1.1.1.1

```

```

Downstream: 10.1.4.41, xe5

```

```

Path refresh: 30 seconds (RR enabled) (due in 25747 seconds)

```

```

Resv lifetime: 157 seconds (due in 139 seconds)

```

```

Retry count: 0, intrvl: 30 seconds

```

```

RRO re-use as ERO: Disabled

```

```

Label Recording: Disabled

```

```

Admin Groups: none

```

```

Configured Path: bypass_1 (in use)

```

```

Configured Explicit Route Detail :

```

```

10.1.4.41/32 strict

```

```

10.3.4.34/32 strict

```

```

Session Explicit Route Detail :

```

```

10.1.4.41/32 strict

```

```

10.3.4.34/32 strict

```

```

Record route:

```

```

-----
IP Address      Label

```

```

-----
<self>
10.1.4.41
10.3.4.34
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
Total LSP protected : 1, Bandwidth in use : 0

```

P1

```

#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes

```

Transit RSVP:

To	From	Type	LSPName	State	Uptime	Rt
Style	Labelin	Labelout	DSType			
3.3.3.3	1.1.1.1	PRI	R1-R3-Primary	UP	00:57:44	1
1 SE	24321	3	ELSP_CON			

Total 1 displayed, Up 1, Down 0.

#show rsvp session de

Transit

3.3.3.3

```

From: 1.1.1.1, LSPstate: Up, LSPname: R1-R3-Primary
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: facility
Fast-Reroute bandwidth : 0
Protection type desired: Link
Fast-Reroute Setup priority: 7, Hold priority: 0
Label in: 24321, Label out: 3
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5001, LSP Id: 2202, Ext-Tunnel Id: 1.1.1.1
Downstream: 10.2.3.32, xe10 Upstream: 10.1.2.12, xe1
Path refresh: 30 seconds (RR enabled) (due in 26500 seconds)
Path lifetime: 157 seconds (due in 126 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 20926 seconds)
Resv lifetime: 157 seconds (due in 151 seconds)
RRO re-use as ERO: Disabled
Label Recording: Enabled
Admin Groups: Received Explicit Route Detail :
10.1.2.21/32 strict
10.2.3.32/32 strict

```

Session Explicit Route Detail :

10.2.3.32/32 strict

Record route:

```

-----
IP Address          Label
-----
10.1.2.12           24321
<self>
10.2.3.32           3
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type:  ELSP_CONFIG
CLASS    DSCP_value    EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls

```

P2

#show rsvp session

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass

State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary

* indicates the session is active with local repair at one or more nodes

Egress RSVP:

To	From	Type	LSPName	State	Uptime	Rt
Style	Labelin	Labelout	DSType			
3.3.3.3	1.1.1.1	PRI	R1-R3-Primary	UP	00:58:47	1
1 SE	3	-	ELSP_CON			
3.3.3.3	1.1.1.1	PRI	B1-B4-Bypass	UP	01:12:30	1
1 SE	3	-	ELSP_CON			

Total 2 displayed, Up 2, Down 0

#show rsvp session detail

Egress

3.3.3.3

From: 1.1.1.1, LSPstate: Up, LSPname: R1-R3-Primary

Egress FSM state: Operational

Setup priority: 7, Hold priority: 0

IGP-Shortcut: Disabled, LSP metric: 65

LSP Protection: facility

Fast-Reroute bandwidth : 0

Protection type desired: Link

Fast-Reroute Setup priority: 7, Hold priority: 0

Label in: 3, Label out: -

Tspec rate: 0, Fspec rate: 0

Tunnel Id: 5001, LSP Id: 2202, Ext-Tunnel Id: 1.1.1.1

Upstream: 10.2.3.23, xe10

Path lifetime: 157 seconds (due in 140 seconds)

Resv refresh: 30 seconds (RR enabled) (due in 37780 seconds)
RRO re-use as ERO: Disabled
Label Recording: Enabled
Admin Groups: Received Explicit Route Detail :
10.2.3.32/32 strict
Record route:

IP Address	Label
------------	-------

10.1.2.12	24321
-----------	-------

10.2.3.23	3
-----------	---

<self>

Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls

Egress

3.3.3.3

From: 1.1.1.1, LSPstate: Up, LSPname: B1-B4-Bypass
Egress FSM state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 3, Label out: -
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5002, LSP Id: 2203, Ext-Tunnel Id: 1.1.1.1
Upstream: 10.3.4.43, xe5
Path lifetime: 157 seconds (due in 134 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 29222 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
10.3.4.34/32 strict
Record route:

IP Address	Label
------------	-------

10.1.4.14	
-----------	--

10.3.4.43	
-----------	--

<self>

Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value

Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls.

PE2

#show rsvp session

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass

State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary

* indicates the session is active with local repair at one or more nodes

Transit RSVP:

To	From	Type	LSPName	State	Uptime	Rt
Style	Labelin	Labelout	DSType			
3.3.3.3	1.1.1.1	PRI	B1-B4-Bypass	UP	01:14:12	1
1 SE	24321	3	ELSP_CON			

Total 1 displayed, Up 1, Down 0.

#show rsvp session detail

Transit

3.3.3.3

From: 1.1.1.1, LSPstate: Up, LSPname: B1-B4-Bypass

Transit upstream state: Operational, downstream state: Operational

Setup priority: 7, Hold priority: 0

IGP-Shortcut: Disabled, LSP metric: 65

LSP Protection: None

Label in: 24321, Label out: 3

Tspec rate: 0, Fspec rate: 0

Tunnel Id: 5002, LSP Id: 2203, Ext-Tunnel Id: 1.1.1.1

Downstream: 10.3.4.34, xe5 Upstream: 10.1.4.14, xe2

Path refresh: 30 seconds (RR enabled) (due in 25543 seconds)

Path lifetime: 157 seconds (due in 146 seconds)

Resv refresh: 30 seconds (RR enabled) (due in 17729 seconds)

Resv lifetime: 157 seconds (due in 135 seconds)

RRO re-use as ERO: Disabled

Label Recording: Disabled

Admin Groups: Received Explicit Route Detail :

10.1.4.41/32 strict

10.3.4.34/32 strict

Session Explicit Route Detail :

10.3.4.34/32 strict

Record route:

IP Address Label

10.1.4.14

<self>

10.3.4.34

Style: Shared Explicit Filter

```
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS      DSCP_value      EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
```

Limitations

Dedicated Bypass Bandwidth

Refer the topology defined above.

Suppose we have two primary tunnels P1 (100mbps) and P2(20mbps) ingressing from R1 and egressing at R3 (path R1->R2>R3) and asking for BW protection and we have two Bypass tunnels bp1 (120mbps) and bp2(80mbps) type dedicated with same ingress and egress router taking Path R1->R4->R3. Below are the two cases defined in which we can observe different kinds of behavior.

1. Let the primary P1 and P2 come up.

CASE 1:

i) If the bypass bp1 (120mbps) comes up first it will give protection to both the primaries P1 and P2. bp2 should remain idle and will not give protection if there are no other primary tunnels asking for it.

CASE 2:

i) If the bypass bp2 (80mbps) comes up first it will give protection to only the primary P2 (20mbps) that will have satisfied protection which will not be changed until the bypass will go down.

ii) After that if bp1 (120mbps) comes it will provide protection to primary P1 (100mbps).

So in the CASE 1 after the protection has been provided to both the primary tunnels P1 and P2 by bypass bp1 if new primary tunnel P3 comes up with BW protection of 80mbps it would be given by bp2 (80mbps).

But in the CASE 2 as bp2 has only 60mbps left (20mbps is being used by P2) and it would not give protection to P3 tunnel and it will remain unprotected. To get the protection new tunnel has to have setup and hold priorities higher than other tunnels which are already been served with the bypass protection.

Secondary Tunnel

Suppose we have primary tunnel P1 (100mbps) ingressing from R1 and egressing at R3 (path R1->R2>R3) and asking for BW protection and we have Bypass tunnel bp1 (120mbps) type dedicated with same ingress and egress router taking Path R1->R4->R3. Then Bypass will start providing protection to primary P1.

If the primary went down it will start using the local protection.

After that if the secondary tunnel is provisioned, primary LSP, which is in using backup state shall continue to use backup path and will not shift over to secondary path.

Facility Bypass with Ring Topology Configuration

This section contains a complete Facility Bypass with Ring Topology configuration.

During facility bypass integration to OcNOS SP, few issues were reported when upstream and downstream interfaces of a session happens to be same (i.e. protection path is same as upstream path) and also CSPF most likely had some issues where LSP path used to formed by crossing the head node of the path.

Considering the information available in RSVP to impose restriction, bypass tunnel path crossing primary LSP node anywhere in between merge point were not considered for mapping.

Below assumption point was added in ERD and documents were updated on the line.

If protection is requested by primary session, then initial bypass matching criteria will be to ensure egress (merge point) node of bypass will be one of the nodes of primary LSP and bypass never intersect any node of primary LSP until the merge point.

The facility bypass method takes advantage of the MPLS label stack. Instead of creating a separate LSP for every backed-up LSP, a single LSP is created that serves to back up a set of LSPs. We call such an LSP tunnel a bypass tunnel. The bypass tunnel must intersect the path of the original LSP(s) somewhere downstream of the PLR. Naturally, this constrains the set of LSPs being backed up via that bypass tunnel to those that pass through some common downstream node. All LSPs that pass through the point of local repair and through this common node that do not also use the facilities involved in the bypass tunnel are candidates for this set of LSPs.

By multiple facility bypass tunnels, we mean that multiple facility bypass tunnels can be created to the same egress/MP. For a protected LSP there could be multiple candidates available. The mapping of the LSP to one of the backup tunnels has to be efficiently done so that we can extract the maximum benefit out of those backup tunnels available

Topology

Figure 2-19 displays a sample Facility Bypass with Ring topology.

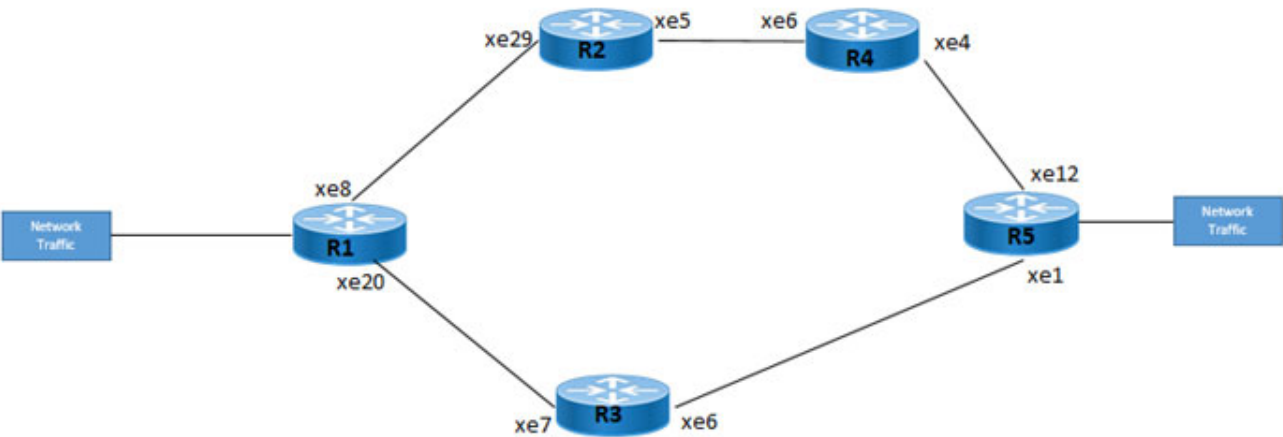


Figure 2-19: Facility Bypass with Ring Topology

Configurations

All configuration commands in the table below should be followed for each router.

R1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback interface.

(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#exit	Exit interface mode.
(config)#bfd interval 3 minrx 3 multiplier	Configure BFD interval
(config)#router-id 1.1.1.1	Assigning router-id
(config)#router rsvp	Enter router mode for RSVP.
(config-router)#exit	Exit router configuration mode.
(config)#interface xe8	Specify the Interface to be configured.
(config-if)#ip address 10.1.1.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe20	Specify the Interface to be configured
(config-if)#ip address 12.1.1.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config-router)#is-type level-1	Configure instance as level-1only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng router-id 1.1.1.1	Configure MPLS-TE unique router-id TLV.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config-router)#bfd all-interfaces	Enable BFD for all neighbors.
(config-router)#net 49.0000.0000.0001.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)#exit	Exit router mode.
(config)#rsvp-path R1-R5-PRI-001	Create a rsvp path
(config-path)#10.1.1.2 strict	Configure this explicit router path as a strict hop
(config-path)#14.1.1.3 strict	Configure this explicit router path as a strict hop
(config-path)#17.1.1.3 strict	Configure this explicit router path as a strict hop
(config-path)#exit	Exit the rsvp-path mode
(config)#rsvp-path R1-R5-BPS-001	Create a rsvp path
(config-path)#12.1.1.2 strict	Configure this explicit router path as a strict hop

(config-path)#15.1.1.3 strict	Configure this explicit router path as a strict hop
(config-path)#exit	Exit the rsvp-path mode
(config)#rsvp-trunk R1-R5-PRI-001	Enter the trunk mode for RSVP
(config-trunk)#primary fast-reroute protection facility	Configure primary fast-reroute protection facility for a trunk.
(config-trunk)#primary fast-reroute node-protection	Configure primary fast-reroute node protection for a trunk.
(config-trunk)#primary path R1-R5-PRI-001	Configure trunk to use the defined path.
(config-trunk)#to 5.5.5.5	Specify the IPv4 egress (destination point) for the LSP
(config-path)#exit	Exit the rsvp-trunk mode
(config)#rsvp-bypass R1-R5-BPS-001	Enter the bypass mode for RSVP
(config-trunk)#path R1-R5-BPS-001	Configure path for bypass tunnel
(config-trunk)#to 5.5.5.5	Specify the IPv4 egress (destination point) for the LSP
(config-path)#exit	Exit the rsvp-bypass mode
(config)#commit	Commit the transaction.

R2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface.
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#exit	Exit interface mode.
(config)#router-id 2.2.2.2	Assigning router-id
(config)#bfd interval 3 minrx 3 multiplier	Configure BFD interval
(config)#router rsvp	Enter router mode for RSVP.
(config-router)#exit	Exit router configuration mode.
(config)#interface xe29	Specify the Interface to be configured.
(config-if)#ip address 10.1.1.2/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe5	Specify the Interface to be configured
(config-if)#ip address 14.1.1.2/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface

(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config-router)#is-type level-1	Configure instance as level-1 only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng router-id 2.2.2.2	Configure MPLS-TE unique router-id TLV.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config-router)#bfd all-interfaces	Enable BFD for all neighbors.
(config-router)#net 49.0000.0000.0002.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)#exit	Exit router mode.
(config)#commit	Commit the transaction.

R3

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface.
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#exit	Exit interface mode.
(config)#router-id 3.3.3.3	Assigning router-id
(config)#bfd interval 3 minrx 3 multiplier	Configure BFD interval
(config)#router rsvp	Enter router mode for RSVP.
(config-router)#exit	Exit router configuration mode.
(config)#interface xe7	Specify the Interface to be configured.
(config-if)#ip address 12.1.1.2/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe6	Specify the Interface to be configured
(config-if)#ip address 15.1.1.2/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.

(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config-router)#is-type level-1	Configure instance as level-1 only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng router-id 3.3.3.3	Configure MPLS-TE unique router-id TLV.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config-router)#bfd all-interfaces	Enable BFD for all neighbors.
(config-router)#net 49.0000.0000.0003.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)#exit	Exit router mode.
(config)#commit	Commit the transaction.

R4

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 4.4.4.4/32 secondary	Configure IP address for the loopback interface.
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#exit	Exit interface mode.
(config)#router-id 4.4.4.4	Assigning router-id
(config)#bfd interval 3 minrx 3 multiplier	Configure BFD interval
(config)#router rsvp	Enter router mode for RSVP.
(config-router)#exit	Exit router configuration mode.
(config)#interface xe4	Specify the Interface to be configured.
(config-if)#ip address 17.1.1.2/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe6	Specify the Interface to be configured
(config-if)#ip address 14.1.1.3/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance

(config-router)#is-type level-1	Configure instance as level-1only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng router-id 4.4.4.4	Configure MPLS-TE unique router-id TLV.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config-router)#bfd all-interfaces	Enable BFD for all neighbors.
(config-router)#net 49.0000.0000.0004.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)#exit	Exit router mode.
(config)#commit	Commit the transaction.

R5

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 5.5.5.5/32 secondary	Configure IP address for the loopback interface.
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#exit	Exit interface mode.
(config)#router-id 5.5.5.5	Assigning router-id
(config)#bfd interval 3 minrx 3 multiplier	Configure BFD interval
(config)#router rsvp	Enter router mode for RSVP.
(config-router)#exit	Exit router configuration mode.
(config)#interface xe12	Specify the Interface to be configured.
(config-if)#ip address 17.1.1.3/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface to be configured
(config-if)#ip address 15.1.1.3/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config-router)#is-type level-1	Configure instance as level-1only routing.

(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng router-id 5.5.5.5	Configure MPLS-TE unique router-id TLV.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config-router)#bfd all-interfaces	Enable BFD for all neighbors.
(config-router)#net 49.0000.0000.0005.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)#exit	Exit router mode.
(config)#commit	Commit the transaction.

Validation

RSVP Session

Validate that the RSVP Session is up.

R1:

```
R1#show rsvp session
```

```
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
```

```
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
```

```
* indicates the session is active with local repair at one or more nodes
```

```
(P) indicates the secondary-priority session is acting as primary
```

```
Ingress RSVP:
```

To Style	Labelin	From Labelout	Type DSType	LSPName	State	Uptime	Rt
5.5.5.5 1 1 SE	-	1.1.1.1 52480	PRI DEFAULT	R1-R5-PRI-001-Primary	UP	00:49:18	
5.5.5.5 1 1 SE	-	1.1.1.1 25600	BPS DEFAULT	R1-R5-BPS-001-Bypass	UP	05:24:23	

Total 2 displayed, Up 2, Down 0.

```
R1#show rsvp session detail
```

```
Ingress (Primary)
```

```
5.5.5.5
```

```
From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-PRI-001-Primary
```

```
Ingress FSM state: Operational
```

```
Establishment Time: 322s 925ms
```

```
Setup priority: 7, Hold priority: 0
```

```
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
```

```
LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: ISIS
```

```
IGP-Shortcut: Disabled, LSP metric: 30
```

```
LSP Protection: facility
```

```
Fast-Reroute bandwidth : 0
```

```
Protection type desired: Node
```

```
Fast-Reroute Hop limit: 255
```

```
Fast-Reroute Setup priority: 7, Hold priority: 0
Bypass trunk: R1-R5-BPS-001, Merge Point: 17.1.1.3, MP Label: 25600
  Bypass OutLabel: 25600, OutIntf: xe20
  Protection provided -> Type: Node, BW: Best-effort
Label in: -, Label out: 52480,
Tspec rate: 0, Fspec rate: 0
Policer: Not Configured
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 1.1.1.1
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 10.1.1.2, xe8
Path refresh: 30 seconds (RR enabled) (due in 27023 seconds)
Resv refresh: 0 seconds (due in 0 seconds)
Resv lifetime: 157 seconds (due in 128 seconds)
Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Enabled
Admin Groups: none
Configured Path: R1-R5-PRI-001 (in use)
Configured Explicit Route Detail :
  10.1.1.2/32 strict
  14.1.1.3/32 strict
  17.1.1.3/32 strict
Session Explicit Route Detail :
  10.1.1.2/32 strict
  14.1.1.3/32 strict
  17.1.1.3/32 strict
Record route:
  LP = 1 -> PLR's Downstream link is protected      PU = 1 -> Protection is in use on
PLR
  NP = 1 -> PLR's Downstream neighbor is protected  BP = 1 -> BW protection available
at PLR
-----
IP Address      Label      (LP, PU, NP, BP)
-----
<self>
10.1.1.2        52480      ( 0,  0,  0,  0)
14.1.1.3        52480      ( 0,  0,  0,  0)
17.1.1.3        25600      ( 0,  0,  0,  0)
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 9216
Recorded Time : N/A
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Last Signaled Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Ingress (Bypass)
5.5.5.5
```

```
From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-BPS-001-Bypass
Ingress FSM state: Operational
Establishment Time: 0s 4ms
Setup priority: 7, Hold priority: 0
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: ISIS
IGP-Shortcut: Disabled, LSP metric: 20
LSP Protection: None
Bypass trunk bandwidth type: Best-effort
  Label in: -, Label out: 25600,
Tspec rate: 0, Fspec rate: 0
Policer: Not Configured
Tunnel Id: 5002, LSP Id: 2205, Ext-Tunnel Id: 1.1.1.1
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 12.1.1.2, xe20
Path refresh: 30 seconds (RR enabled) (due in 10514 seconds)
Resv lifetime: 157 seconds (due in 141 seconds)
Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Configured Path: R1-R5-BPS-001 (in use)
Configured Explicit Route Detail :
  12.1.1.2/32 strict
  15.1.1.3/32 strict
Session Explicit Route Detail :
  12.1.1.2/32 strict
  15.1.1.3/32 strict
Record route:
-----
IP Address      Label
-----
<self>
12.1.1.2
15.1.1.3
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 9216
Recorded Time : N/A
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Last Signaled Error:
  Code : RSVP System error (23), Value : N/A (0)
  Originated Node : 15.1.1.3, Recorded Time : 2023 May 16 08:52:51
Trunk Type: mpls
Total LSP protected : 1, Bandwidth in use : 0
```

R2:

R2#show rsvp session

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
 State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
 * indicates the session is active with local repair at one or more nodes
 (P) indicates the secondary-priority session is acting as primary

Transit RSVP:

To	From	Type	LSPName	State	Uptime	Rt
Style	Labelin	Labelout	DSType			
5.5.5.5	1.1.1.1	PRI	R1-R5-PRI-001-Primary	UP	00:49:59	
1 1 SE	52480	52480	ELSP_CON			

Total 1 displayed, Up 1, Down 0.

R2#show rsvp session detail

Transit

5.5.5.5

From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-PRI-001-Primary
 Transit upstream state: Operational, downstream state: Operational
 Setup priority: 7, Hold priority: 0
 IGP-Shortcut: Disabled, LSP metric: 65
 LSP Protection: facility
 Fast-Reroute bandwidth : 0
 Protection type desired: Node
 Fast-Reroute Hop limit: 255
 Fast-Reroute Setup priority: 7, Hold priority: 0
 Label in: 52480, Label out: 52480,
 Tspec rate: 0, Fspec rate: 0
 Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 1.1.1.1
 Bind value: 0, Oper state: NA, Alloc mode: NA
 Downstream: 14.1.1.3, xe5 Upstream: 10.1.1.1, xe29
 Path refresh: 30 seconds (RR enabled) (due in 27004 seconds)
 Path lifetime: 157 seconds (due in 130 seconds)
 Resv refresh: 30 seconds (RR enabled) (due in 19943 seconds)
 Resv lifetime: 157 seconds (due in 141 seconds)
 RRO re-use as ERO: Disabled
 Label Recording: Enabled
 Admin Groups: Received Explicit Route Detail :
 10.1.1.2/32 strict
 14.1.1.3/32 strict
 17.1.1.3/32 strict
 Session Explicit Route Detail :
 14.1.1.3/32 strict
 17.1.1.3/32 strict
 Record route:

```

-----
IP Address      Label
-----
10.1.1.1        52480
<self>
14.1.1.3        52480
17.1.1.3        25600

```

Style: Shared Explicit Filter
 Traffic type: controlled-load
 Minimum Path MTU: 9216
 LSP Type: ELSP_CONFIG
 CLASS DSCP_value EXP_value
 Current Error:
 Code : None, Value : None
 Originated Node : None, Recorded Time : N/A
 Trunk Type: mpls

R3:

R3#show rsvp session
 Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
 State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
 * indicates the session is active with local repair at one or more nodes
 (P) indicates the secondary-priority session is acting as primary

Transit RSVP:

To	From	Type	LSPName	State	Uptime	Rt
Style	Labelin	Labelout	DSType			
5.5.5.5	1.1.1.1	PRI	R1-R5-BPS-001-Bypass	UP	05:25:48	
1 1 SE	25600	3	ELSP_CON			

Total 1 displayed, Up 1, Down 0.

R3#show rsvp session detail

Transit

5.5.5.5

From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-BPS-001-Bypass
 Transit upstream state: Operational, downstream state: Operational
 Setup priority: 7, Hold priority: 0
 IGP-Shortcut: Disabled, LSP metric: 65
 LSP Protection: None
 Label in: 25600, Label out: 3,
 Tspec rate: 0, Fspec rate: 0
 Tunnel Id: 5002, LSP Id: 2205, Ext-Tunnel Id: 1.1.1.1
 Bind value: 0, Oper state: NA, Alloc mode: NA
 Downstream: 15.1.1.3, xe6 Upstream: 12.1.1.1, xe7
 Path refresh: 30 seconds (RR enabled) (due in 10445 seconds)
 Path lifetime: 157 seconds (due in 155 seconds)
 Resv refresh: 30 seconds (RR enabled) (due in 24008 seconds)
 Resv lifetime: 157 seconds (due in 140 seconds)
 RRO re-use as ERO: Disabled
 Label Recording: Disabled
 Admin Groups: Received Explicit Route Detail :
 12.1.1.2/32 strict
 15.1.1.3/32 strict
 Session Explicit Route Detail :
 15.1.1.3/32 strict
 Record route:

```
IP Address      Label
-----
12.1.1.1
<self>
15.1.1.3
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 9216
LSP Type:  ELSP_CONFIG
CLASS      DSCP_value      EXP_value
Recorded Time : N/A
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
R3#

R4:
R4#show rsvp session
Type   : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State  : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Transit RSVP:
To      From      Type      LSPName      State Uptime      Rt
Style  Labelin  Labelout  DSType
5.5.5.5      1.1.1.1      PRI      R1-R5-PRI-001-Primary      UP      00:51:13
1 1 SE      52480      25600      ELSP_CON
Total 1 displayed, Up 1, Down 0.

R4#show rsvp session detail
Transit
5.5.5.5
  From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-PRI-001-Primary
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Node
  Fast-Reroute Hop limit: 255
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Label in: 52480, Label out: 25600,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 1.1.1.1
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 17.1.1.3, xe4 Upstream: 14.1.1.2, xe6
  Path refresh: 30 seconds (RR enabled) (due in 26908 seconds)
  Path lifetime: 157 seconds (due in 148 seconds)
```

Resv refresh: 30 seconds (RR enabled) (due in 37164 seconds)
Resv lifetime: 157 seconds (due in 144 seconds)
RRO re-use as ERO: Disabled
Label Recording: Enabled
Admin Groups: Received Explicit Route Detail :
14.1.1.3/32 strict
17.1.1.3/32 strict
Session Explicit Route Detail :
17.1.1.3/32 strict
Record route:

```
-----  
IP Address      Label  
-----  
10.1.1.1        52480  
14.1.1.2        52480  
<self>  
17.1.1.3        25600  
Style: Shared Explicit Filter  
Traffic type: controlled-load  
Minimum Path MTU: 9216  
LSP Type: ELSP_CONFIG  
CLASS    DSCP_value    EXP_value  
Current Error:  
Code : None, Value : None  
Originated Node : None, Recorded Time : N/A  
Trunk Type: mpls
```

R5:

R5#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Egress RSVP:

To	From	Type	LSPName	State	Uptime	Rt
Style	Labelin	Labelout	DSType			
5.5.5.5	1.1.1.1	PRI	R1-R5-PRI-001-Primary	UP	00:51:45	
1 1 SE	25600	-	ELSP_CON			
5.5.5.5	1.1.1.1	PRI	R1-R5-BPS-001-Bypass	UP	05:26:50	
1 1 SE	3	-	ELSP_CON			

Total 2 displayed, Up 2, Down 0.

R5#show rsvp session detail
Egress
5.5.5.5
From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-PRI-001-Primary
Egress FSM state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65

```
LSP Protection: facility
Fast-Reroute bandwidth : 0
Protection type desired: Node
Fast-Reroute Hop limit: 255
Fast-Reroute Setup priority: 7, Hold priority: 0
Label in: 25600, Label out: -,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 1.1.1.1
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 17.1.1.2, xe12
Path lifetime: 157 seconds (due in 126 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 28434 seconds)
RRO re-use as ERO: Disabled
Label Recording: Enabled
Admin Groups: Received Explicit Route Detail :
  17.1.1.3/32 strict
Record route:
-----
IP Address      Label
-----
10.1.1.1        52480
14.1.1.2        52480
17.1.1.2        25600
<self>
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 9216
LSP Type: ELSP_CONFIG
CLASS    DSCP_value    EXP_value
Recorded Time : N/A
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Egress
5.5.5.5
From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-BPS-001-Bypass
Egress FSM state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 3, Label out: -,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5002, LSP Id: 2205, Ext-Tunnel Id: 1.1.1.1
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 15.1.1.2, xe1
Path lifetime: 157 seconds (due in 141 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 927 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
```


Admin Groups: Received Explicit Route Detail :
15.1.1.3/32 strict

Record route:

```
-----
IP Address      Label
-----
```

12.1.1.1

15.1.1.2

<self>

Style: Shared Explicit Filter

Traffic type: controlled-load

Minimum Path MTU: 9216

LSP Type: ELSP_CONFIG

CLASS DSCP_value EXP_value

Recorded Time : N/A

Current Error:

Code : None, Value : None

Originated Node : None, Recorded Time : N/A

Trunk Type: mpls

RSVP Bypass

Validate that the RSVP bypass session is up.

R1:

R1#show rsvp bypass

Ingress RSVP:

To	From	LSPName	State	Uptime	Rt	Style
Labelin	Labelout	DSType				
5.5.5.5	1.1.1.1	R1-R5-BPS-001-Bypass	UP	05:27:41	1 1	SE
-	25600	DEFAULT				

To validate RSVP bypass session details:

R1#show rsvp bypass detail

Ingress (Bypass)

5.5.5.5

From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-BPS-001-Bypass

Ingress FSM state: Operational

Establishment Time: 0s 4ms

Setup priority: 7, Hold priority: 0

CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds

LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: ISIS

IGP-Shortcut: Disabled, LSP metric: 20

LSP Protection: None

Bypass trunk bandwidth type: Best-effort

Label in: -, Label out: 25600,

Tspec rate: 0, Fspec rate: 0

Policer: Not Configured

Tunnel Id: 5002, LSP Id: 2205, Ext-Tunnel Id: 1.1.1.1

Bind value: 0, Oper state: NA, Alloc mode: NA

Downstream: 12.1.1.2, xe20

Path refresh: 30 seconds (RR enabled) (due in 10319 seconds)

```
Resv lifetime: 157 seconds (due in 126 seconds)
Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Configured Path: R1-R5-BPS-001 (in use)
Configured Explicit Route Detail :
  12.1.1.2/32 strict
  15.1.1.3/32 strict
Session Explicit Route Detail :
  12.1.1.2/32 strict
  15.1.1.3/32 strict
Record route:
-----
IP Address          Label
-----
<self>
12.1.1.2
15.1.1.3
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 9216
Recorded Time : N/A
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Last Signaled Error:
  Code : RSVP System error (23), Value : N/A (0)
  Originated Node : 15.1.1.3, Recorded Time : 2023 May 16 08:52:51
Trunk Type: mpls
Total LSP protected : 1, Bandwidth in use : 0
```

To validate RSVP bypass Protected-lsp-list:

```
R1#show rsvp bypass protected-lsp-list
Bypass trunk: R1-R5-BPS-001
Bypass trunk bandwidth type: best-effort
List of LSP's Protected:
Tunnel-id      Lsp Id      Lsp Name                      Role      Ext_tnl_id  Ingress
Egress
5001           2201        R1-R5-PRI-001-Primary         Ingress   1.1.1.1     1.1.1.1
5.5.5.5
Total LSP protected : 1
Bandwidth in use : 0
```

CHAPTER 3 RSVP-Multipath Configuration

RSVP multipath provides multiple paths to reach the destination. RSVP services (L2 VPN, L3 VPN, LU, mapped route, etc.) can be mapped to RSVP multipath so that traffic is load-balanced. At ingress node the traffic is load-balanced based on the configured hash (L3 src/dest IP/port, L2 src/dst mac, or in-label if intermediate Autonomous segments). Each LSP path within multipath group can provide individual protection for each path (facility, 1-to-1, secondary). Each tunnel path in multipath group cost may vary (can have different hop, with consideration for load-balancing the traffic). Each member can have the backup protection as other multipath member path or outside the multipath member path.

Topology

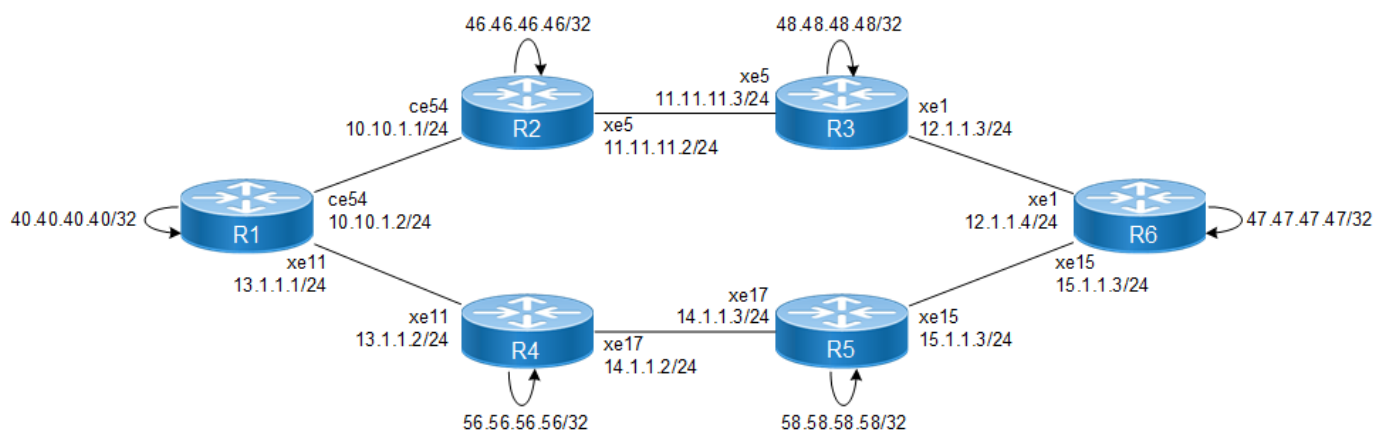


Figure 3-20: RSVP-Multipath Topology

Configuration

R1

#configure terminal	Enter configure mode.
(config)#hardware-profile statistics tunnel-lif enable	Configure hardware-profile statistics
(config)#interface lo	Enter interface mode.
(config-if)#ip address 40.40.40.40/32 secondary	Set a secondary IP address of the interface.
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enter Configure Router mode.
(config-router)#router-id 40.40.40.40	Set the router ID to IP address 40.40.40.40
(config-router)#exit	Exit Router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.10.1.1/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.

(config-if)#exit	Exit interface mode.
(config)#interface xel1	Enter interface mode.
(config-if)#ip address 13.1.1.1/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the Routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 40.40.40.40	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.1.1.0/24 area 0	Define the network (10.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 13.1.1.0/24 area 0	Define the network (13.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 40.40.40.40/32 area 0	Set the IP address of the loopback interface to 40.40.40.40/32.
(config-router)#exit	Exit Router mode.
(config)#rsvp-path path1 mpls	Enter the path mode for RSVP path1.
(config-path)#10.1.1.2 strict	Configure this explicit route path as a strict hop.
(config-path)#11.1.1.3 strict	Configure this explicit route path as a strict hop.
(config-path)#12.1.1.4 strict	Configure this explicit route path as a strict hop.
(config)#exit	Exit the path mode.
(config)#rsvp-path path2 mpls	Enter the path mode for RSVP path2.
(config-path)#13.1.1.2 strict	Configure this explicit route path as a strict hop.
(config-path)#14.1.1.3 strict	Configure this explicit route path as a strict hop.
(config-path)#15.1.1.4 strict	Configure this explicit route path as a strict hop.
(config)#exit	Exit the path mode.
(config)#rsvp-trunk t1 ipv4	Enter the trunk mode for rsvp.
(config-trunk)#primary path path1	Configure trunk t1 to use the defined path.
(config-trunk)#from 40.40.40.40	Specify the IPv4 ingress (source point) for the LSP.
(config-trunk)#to 47.47.47.47	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#exit	Exit from trunk mode.
(config)#rsvp-trunk t2 ipv4	Enter the trunk mode for rsvp.
(config-trunk)#primary path path2	Configure trunk t2 to use the defined path.
(config-trunk)#from 40.40.40.40	Specify the IPv4 egress (source point) for the LSP.
(config-trunk)#to 47.47.47.47	Specify the IPv4 ingress (destination point) for the LSP.
(config-trunk)#exit	Exit from trunk mode.
(config)#rsvp-multipath test	Configure RSVP Multipath group.
(config-multipath)#to 47.47.47.47	Configure a mandatory destination FEC(egress router).
(config-multipath)#description "my-group"	Configure description to RSVP Multipath group.
(config-multipath)#exit	Exit from RSVP Multipath mode.
(config)#rsvp-trunk t1 ipv4	Enter the trunk mode for rsvp.

(config-trunk)#multipath-group test	Configure RSVP Multipath group to trunk t1.
(config-trunk)#exit	Exit from trunk mode.
(config)#rsvp-trunk t2 ipv4	Enter the trunk mode for rsvp.
(config-trunk)#multipath-group test	Configure RSVP Multipath group to trunk t2.
(config-trunk)#exit	Exit from trunk mode.
(config)#commit	Commit all the configurations.

R2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 46.46.46.46/32 secondary	Set a secondary IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.10.1.2/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe5	Enter interface mode.
(config-if)#ip address 11.1.1.2/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the Routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 46.46.46.46	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.1.1.0/24 area 0	Define the network (10.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 11.1.1.0/24 area 0	Define the network (11.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 46.46.46.46/32 area 0	Set the IP address of the loopback interface to 46.46.46.46/ 32.
(config-router)#exit	Exit Router mode.
(config)#commit	Commit all the configurations.

R3

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.

(config-if)#ip address 48.48.48.48/32 secondary	Set a secondary IP address of the interface.
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 12.1.1.3/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe5	Enter interface mode.
(config-if)#ip address 11.1.1.3/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the Routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 48.48.48.48	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 11.1.1.0/24 area 0	Define the network (11.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 12.1.1.0/24 area 0	Define the network (12.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 48.48.48.48/32 area 0	Set the IP address of the loopback interface to 48.48.48.48/32.
(config-router)#exit	Exit Router mode.
(config)#commit	Commit all the configurations.

R4

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 56.56.56.56/32 secondary	Set a secondary IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe11	Enter interface mode.
(config-if)#ip address 13.1.1.2/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe17	Enter interface mode.

(config-if)#ip address 14.1.1.2/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the Routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 56.56.56.56	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 13.1.1.0/24 area 0	Define the network (13.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 14.1.1.0/24 area 0	Define the network (14.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 56.56.56.56/32 area 0	Set the IP address of the loopback interface to 56.56.56.56/32.
(config-router)#exit	Exit Router mode.
(config)#commit	Commit all the configurations.

R5

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 58.58.58.58/32 secondary	Set a secondary IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 15.1.1.3/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe17	Enter interface mode.
(config-if)#ip address 14.1.1.3/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the Routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 58.58.58.58	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 15.1.1.0/24 area 0	Define the network (15.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 14.1.1.0/24 area 0	Define the network (14.1.1.0/24) on which OSPF runs and associate the area ID (0).

(config-router)#network 58.58.58.58/32 area 0	Set the IP address of the loopback interface to 58.58.58.58/32.
(config-router)#exit	Exit Router mode.
(config)#commit	Commit all the configurations.

R6

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 47.47.47.47/32 secondary	Set a secondary IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 12.1.1.4/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 15.1.1.4/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the Routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 47.47.47.47	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 12.1.1.0/24 area 0	Define the network (12.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 15.1.1.0/24 area 0	Define the network (15.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 47.47.47.47/32 area 0	Set the IP address of the loopback interface to 47.47.47.47/32.
(config-router)#exit	Exit Router mode.
(config)#commit	Commit all the configurations.

Validation

R1

```
#show ip ospf neighbor
```

```
Total number of full neighbors: 2
OSPF process 1 VRF(default):
```


Neighbor ID Instance ID	Pri	State	Dead Time	Address	Interface
46.46.46.46 0	1	Full/DR	00:00:38	10.1.1.2	ce54
56.56.56.56 0	1	Full/DR	00:00:37	13.1.1.2	xe11

```
#show rsvp session
```

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
 State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
 * indicates the session is active with local repair at one or more nodes
 (P) indicates the secondary-priority session is acting as primary

```
Ingress RSVP:
```

To Labelin	From Labelout	DSType	Type	LSPName	State	Uptime	Rt	Style
47.47.47.47 -	40.40.40.40 24320	DEFAULT	PRI	t1-Primary	UP	00:01:46	1 1	SE
47.47.47.47 -	40.40.40.40 24320	DEFAULT	PRI	t2-Primary	UP	00:01:46	1 1	SE

Total 2 displayed, Up 2, Down 0.

```
#show rsvp multipath
```

```
RSVP-multipath Name : test, ID : 101
Description : "my-group"
Member count : 2, Egress : 47.47.47.47/32
Member details :
-----
Trunk-ID   Trunk-name   Status
5001       t1            active
5002       t2            active
```

```
#show mpls rsvp-multipath
```

Codes: > - installed FTN, * - selected FTN, t - tunnel, R - RSVP-TE FTN

```
Multipath Name : test, ID : 101, Nhlfe Ix : 4
Active member count : 2, FEC : 47.47.47.47/32
Active member details :
```

Index Out-Intf	Code ELC	FTN-ID Nexthop	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
1 ce54	R(t)> No	1 10.1.1.2	3	5001	Yes	LSP_DEFAULT	24320
2 xe11	R(t)> No	2 13.1.1.2	5	5002	Yes	LSP_DEFAULT	24320

```
#show mpls counters rsvp multipath-name test
```

```
Tunnel-id 5001 Extended Tunnel-ID 40.40.40.40 Egress 47.47.47.47
lsp-name : t1-Primary [Ingress]
lsp-ingress : 40.40.40.40 lsp-id : 2201
Rx pkts : n/a Rx bytes : n/a
Tx pkts : 864364 Tx bytes : 1298276230
```

```
Tunnel-id 5002 Extended Tunnel-ID 40.40.40.40 Egress 47.47.47.47
```

```
lsp-name : t2-Primary [Ingress]
lsp-ingress : 40.40.40.40    lsp-id : 2202
Rx pkts : n/a              Rx bytes : n/a
Tx pkts : 864366           Tx bytes : 1298277732

#show mpls ftn-table
Primary FTN entry with FEC: 47.47.47.47/32, id: 1, row status: Active,
Tunnel-Policy: N/A
  Owner: RSVP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0,
Incoming DSCP: none
  Tunnel id: 5001, Protected LSP id: 2201, QoS Resource id: 2, Description:
t1, Color: 0
  Multipath group: test
    Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 3
    Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 3, owner: RSVP, Stale: NO, out intf: ce54, out
label: 24320
    Nexthop addr: 10.1.1.2      cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 47.47.47.47/32, id: 2, row status: Active,
Tunnel-Policy: N/A
  Owner: RSVP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0,
Incoming DSCP: none
  Tunnel id: 5002, Protected LSP id: 2202, QoS Resource id: 3, Description:
t2, Color: 0
  Multipath group: test
    Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 5
    Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 5, owner: RSVP, Stale: NO, out intf: xell, out
label: 24320
    Nexthop addr: 13.1.1.2      cross connect ix: 4, op code: Push

#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
      B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
      L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
      U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code    FEC          FTN-ID   Nhlfe-ID  Tunnel-id  Pri   LSP-Type
Out-Label Out-Intf   ELC     Nexthop
R(t)>    47.47.47.47/32  1        3         5001       Yes   LSP_DEFAULT
24320   ce54       No      10.1.1.2
R(t)>    47.47.47.47/32  2        5         5002       Yes   LSP_DEFAULT
24320   xell       No      13.1.1.2

#show rsvp session detail
Egress
40.40.40.40
  From: 47.47.47.47, LSPstate: Up, LSPname: PE2-PE1-Primary
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: 24960, Label out: -,
  Tspec rate: 0k, Fspec rate: 0k
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 47.47.47.47
```

```
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 13.1.1.2, xell
Path lifetime: 157 seconds (due in 146 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 34571 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
  13.1.1.1/32 strict
Record route:
-----
IP Address      Label
-----
15.1.1.4
14.1.1.3
13.1.1.2
<self>
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS    DSCP_value    EXP_value
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Ingress (Primary)
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t1-Primary
Ingress FSM state: Operational
Establishment Time: 0s 22ms
Setup priority: 7, Hold priority: 0
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
IGP-Shortcut: Disabled, LSP metric: 3
LSP Protection: None
Label in: -, Label out: 24320,
Tspec rate: 0k, Fspec rate: 0k
Policer: Not Configured
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 10.1.1.2, ce54
Path refresh: 30 seconds (RR enabled) (due in 29859 seconds)
Resv lifetime: 157 seconds (due in 149 seconds)
Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Configured Path: path1 (in use)
Configured Explicit Route Detail :
  10.1.1.2/32 strict
  11.1.1.3/32 strict
  12.1.1.4/32 strict
Session Explicit Route Detail :
  10.1.1.2/32 strict
  11.1.1.3/32 strict
  12.1.1.4/32 strict
Record route:
```

```
-----
IP Address      Label
-----
<self>
10.1.1.2
11.1.1.3
12.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Last Signaled Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Ingress (Primary)
47.47.47.47
  From: 40.40.40.40, LSPstate: Up, LSPname: t2-Primary
  Ingress FSM state: Operational
  Establishment Time: 0s 30ms
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
  IGP-Shortcut: Disabled, LSP metric: 3
  LSP Protection: None
  Label in: -, Label out: 24320,
  Tspec rate: 0k, Fspec rate: 0k
  Policer: Not Configured
  Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 40.40.40.40
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 13.1.1.2, xell
  Path refresh: 30 seconds (RR enabled) (due in 29850 seconds)
  Resv lifetime: 157 seconds (due in 146 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: path2 (in use)
  Configured Explicit Route Detail :
    13.1.1.2/32 strict
    14.1.1.3/32 strict
    15.1.1.4/32 strict
  Session Explicit Route Detail :
    13.1.1.2/32 strict
    14.1.1.3/32 strict
    15.1.1.4/32 strict
  Record route:
-----
IP Address      Label
-----
<self>
13.1.1.2
14.1.1.3
15.1.1.4
Style: Shared Explicit Filter
```

Traffic type: controlled-load
Minimum Path MTU: 1500
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Last Signaled Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls

#show mpls ilm-table

Codes: > - installed ILM, * - selected ILM, p - stale ILM
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
S - SNMP, L - LDP, R - RSVP, C - CRLDP
B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
P - SR Policy, U - unknown

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-
Intf/VRF	Nextthop		LSP-Type			
B> vrf-PE1		1	24320	Nolabel	N/A	vrf-
PE1	N/A		LSP_DEFAULT			
R> 40.40.40.40/32		2	24960	Nolabel	N/A	
127.0.0.1		ELSP_CONFIG				

R2#show ip ospf neighbor

Total number of full neighbors: 2

OSPF process 1 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
40.40.40.40	1	Full/Backup	00:00:37	10.10.1.1	xe1	0
48.48.48.48	1	Full/Backup	00:00:34	11.1.1.3	xe12	0

R2#show rsvp session

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass

State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary

* indicates the session is active with local repair at one or more nodes

(P) indicates the secondary-priority session is acting as primary

Transit RSVP:

To From Type LSPName State Uptime Rt Style Labelin Labelout DStype

47.47.47.47 40.40.40.40 PRI t1-Primary UP 00:14:13 1 1 SE 25600 25600 ELSP_CON

Total 1 displayed, Up 1, Down 0.

R2#

R2#

R2#

R2#show rsvp session detail

Transit

47.47.47.47

From: 40.40.40.40, LSPstate: Up, LSPname: t1-Primary

Transit upstream state: Operational, downstream state: Operational

```

Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 25600, Label out: 25600,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 11.1.1.3, xe12 Upstream: 10.10.1.1, xe1
Path refresh: 30 seconds (RR enabled) (due in 29011 seconds)
Path lifetime: 157 seconds (due in 133 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 32105 seconds)
Resv lifetime: 157 seconds (due in 133 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
10.10.1.2/32 strict
11.1.1.3/32 strict
12.1.1.4/32 strict
Session Explicit Route Detail :
11.1.1.3/32 strict
12.1.1.4/32 strict
Record route:
-----
IP Address Label
-----
10.10.1.1
<self>
11.1.1.3
12.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Recorded Time : N/A
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
R2#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
S - SNMP, L - LDP, R - RSVP, C - CRLDP
B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
P - SR Policy, U - unknown
LDP ilm-ecmp - disabled
Code FEC/VRF/L2CKT ILM-ID In-Label Out-Label In-Intf Out-Intf/VRF Nexthop pri
LSP-Type
R> 47.47.47.47/32 1 25600 25600 N/A xe12 11.1.1.3 Yes ELSP_CONFIG
R3#show ip ospf neighbor
Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID Pri State Dead Time Address Interface Instance ID
46.46.46.46 1 Full/DR 00:00:31 11.1.1.2 xe40 0
47.47.47.47 1 Full/Backup 00:00:32 12.1.1.4 xe6
R3#show rsvp session

```

```

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS -
Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
Transit RSVP:
To From Type LSPName State Uptime Rt Style Labelin Labelout DStype
47.47.47.47 40.40.40.40 PRI t1-Primary UP 00:20:52 1 1 SE 25600 25600 ELSP_CON
Total 1 displayed, Up 1, Down 0.
R3#show rsvp session detail
Transit
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t1-Primary
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 25600, Label out: 25600,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 12.1.1.4, xe1 Upstream: 11.1.1.2, xe5
Path refresh: 30 seconds (RR enabled) (due in 28622 seconds)
Path lifetime: 157 seconds (due in 151 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 41536 seconds)
Resv lifetime: 157 seconds (due in 141 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
11.1.1.3/32 strict
12.1.1.4/32 strict
Session Explicit Route Detail :
12.1.1.4/32 strict
Record route:
-----
IP Address Label
-----
10.10.1.1
11.1.1.2
<self>
12.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Recorded Time : N/A
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
R3# R3#show rsvp session detail
Transit
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t1-Primary
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0

```

```

IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 25600, Label out: 25600,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 12.1.1.4, xe6 Upstream: 11.1.1.2, xe40
Path refresh: 30 seconds (RR enabled) (due in 28622 seconds)
Path lifetime: 157 seconds (due in 151 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 41536 seconds)
Resv lifetime: 157 seconds (due in 141 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
11.1.1.3/32 strict
12.1.1.4/32 strict
Session Explicit Route Detail :
12.1.1.4/32 strict
Record route:
-----
IP Address Label
-----
10.10.1.1
11.1.1.2
<self>
12.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Recorded Time : N/A
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
R3#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
S - SNMP, L - LDP, R - RSVP, C - CRLDP
B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
O - OSPF/OSPF6 SR, i - ISIS_SR, k - SR CLI
P - SR Policy, U - unknown
LDP ilm-ecmp - disabled
Code FEC/VRF/L2CKT ILM-ID In-Label Out-Label In-Intf Out-Intf/VRF Nexthop pri
LSP-Type
R> 47.47.47.47/32 1 25600 25600 N/A xe6 12.1.1.4 Yes ELSP_CONFIG
R4:
R4#show ip ospf neighbor
Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID Pri State Dead Time Address Interface Instance ID
40.40.40.40 1 Full/Backup 00:00:33 13.1.1.1 xe2 0
58.58.58.58 1 Full/DR 00:00:39 14.1.1.3 xe3 0

R4#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass

```


State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
Transit RSVP:
To From Type LSPName State Uptime Rt Style Labelin Labelout DStype
47.47.47.47 40.40.40.40 PRI t2-Primary UP 00:54:24 1 1 SE 24320 52480 ELSP_CON
Total 1 displayed, Up 1, Down 0.
R4#show rsvp session detail
Transit
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t2-Primary
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 24320, Label out: 52480,
Tspec rate: 0k, Fspec rate: 0k
Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 14.1.1.3, xe3 Upstream: 13.1.1.1, xe2
Path refresh: 30 seconds (RR enabled) (due in 26617 seconds)
Path lifetime: 157 seconds (due in 143 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 36430 seconds)
Resv lifetime: 157 seconds (due in 143 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
13.1.1.2/32 strict
14.1.1.3/32 strict
15.1.1.4/32 strict
Session Explicit Route Detail :
14.1.1.3/32 strict
15.1.1.4/32 strict
Record route:

IP Address Label

13.1.1.1
<self>
14.1.1.3
15.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls R4#
R4#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
S - SNMP, L - LDP, R - RSVP, C - CRLDP
B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI

```

P - SR Policy, U - unknown
Code FEC/VRF/L2CKT ILM-ID In-Label Out-Label In-Intf Out-Intf/VRF Nexthop LSP-
Type
R> 47.47.47.47/32 1 24320 52480 N/A xe3 14.1.1.3 ELSP_CONFIG
R5#show ip ospf neighbor
Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID Pri State Dead Time Address Interface Instance ID
56.56.56.56 1 Full/Backup 00:00:39 14.1.1.2 xe42 0
47.47.47.47 1 Full/DR 00:00:38 15.1.1.4 xe39 0
R5#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS -
Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
Transit RSVP:
To From Type LSPName State Uptime Rt Style Labelin Labelout DStype
47.47.47.47 40.40.40.40 PRI t2-Primary UP 00:59:48 1 1 SE 52480 25601 ELSP_CON
Total 1 displayed, Up 1, Down 0.
R5#show rsvp session detail
Transit
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t2-Primary
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 52480, Label out: 25601,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 15.1.1.4, xe39 Upstream: 14.1.1.2, xe42
Path refresh: 30 seconds (RR enabled) (due in 26344 seconds)
Path lifetime: 157 seconds (due in 149 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 37267 seconds)
Resv lifetime: 157 seconds (due in 132 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
14.1.1.3/32 strict
15.1.1.4/32 strict
Session Explicit Route Detail :
15.1.1.4/32 strict
Record route:
-----
IP Address Label
-----
13.1.1.1
14.1.1.2

<self>
15.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG

```

```
CLASS DSCP_value EXP_value
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
R5#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
S - SNMP, L - LDP, R - RSVP, C - CRLDP
B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
U - unknown
Code FEC/VRF/L2CKT ILM-ID In-Label Out-Label In-Intf Out-Intf/VRF Nexthop pri
LSP-Type
R> 47.47.47.47/32 1 52480 25601 N/A xe39 15.1.1.4 Yes ELSP_CONFIG
R5#
R5#
```

R6:

```
R6#show ip ospf neighbor
Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID Pri State Dead Time Address Interface Instance ID
48.48.48.48 1 Full/DR 00:00:30 12.1.1.3 xe6 0
58.58.58.58 1 Full/Backup 00:00:33 15.1.1.3 xe5 0
R6#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS -
Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
Egress RSVP:
To From Type LSPName State Uptime Rt Style Labelin Labelout DStype
47.47.47.47 40.40.40.40 PRI t1-Primary UP 01:05:33 1 1 SE 25600 - ELSP_CON
47.47.47.47 40.40.40.40 PRI t2-Primary UP 01:04:57 1 1 SE 25601 - ELSP_CON
Total 2 displayed, Up 2, Down 0.
R6#
R6#show rsvp session detail
Egress
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t1-Primary
Egress FSM state: Operational

Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 25600, Label out: -,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 12.1.1.3, xe6
Path lifetime: 157 seconds (due in 143 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 19100 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
```

```
12.1.1.4/32 strict
Record route:
-----
IP Address Label
-----
10.10.1.1
11.1.1.2
12.1.1.3
<self>
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Recorded Time : N/A
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Egress
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t2-Primary
Egress FSM state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 25601, Label out: -,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 15.1.1.3, xe5
Path lifetime: 157 seconds (due in 156 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 30939 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
15.1.1.4/32 strict
Record route:
-----
IP Address Label
-----
13.1.1.1
14.1.1.2
15.1.1.3
<self>
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Recorded Time : N/A
Current Error:

Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
R6#show mpls ilm-table
```

Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
S - SNMP, L - LDP, R - RSVP, C - CRLDP
B - BGP, K - CLI, V - LDP_VC, I - IGP_SHORTCUT
O - OSPF/OSPF6 SR, i - ISIS_SR, k - SR_CLI
P - SR Policy, U - unknown
LDP ilm-ecmp - disabled
Code FEC/VRF/L2CKT ILM-ID In-Label Out-Label In-Intf Out-Intf/VRF Nexthop pri
LSP-Type
R> 47.47.47.47/32 1 25600 Nolabel N/A N/A 127.0.0.1 Yes ELSP_CONFIG
R> 47.47.47.47/32 2 25601 Nolabel N/A N/A 127.0.0.1 Yes ELSP_CONFIG

CHAPTER 4 RSVP Graceful Restart Configuration

Overview

The RSVP-TE graceful restart enables routers to maintain MPLS forwarding state when a link or node failure occurs. In a link failure, control communication is lost between two nodes, however, the nodes do not lose their control or forwarding state. RSVP Graceful restart (GR) is one of the fault-handling mechanism, that protects the forwarding state of the node during failure and helps to reinstate the previous state when the node has recovered.

Topology

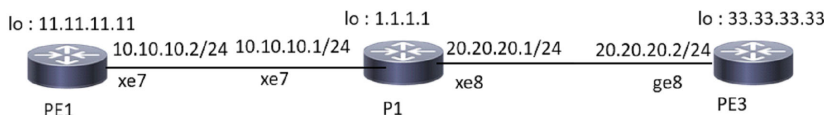


Figure 4-21: RSVP Graceful Restart

Configuration

PE1-NSM

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 11.11.11.11/32 secondary	Set the IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe7	Enter interface mode.
(config-if)#ip address 10.10.10.2/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface xe7.
(config-if)#commit	Commit the transaction.

PE1-RSVP-TE

(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe7	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#commit	Commit the transaction.

PE1-OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 11.11.11.11	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.10.10.0/24 area 0	Define the network (10.10.10.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 11.11.11.11/32 area 0	Set the IP address of the loopback interface to 11.11.11.11/32.
(config-router)#commit	Commit the transaction.

P - NSM

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address for the interface.
(config-if)#exit	Enable label switching on interface lo.
(config)#interface xe7	Enter interface mode.
(config-if)#ip address 10.10.10.1/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface xe7.
(config-if)#exit	Exit interface mode.
(config)#interface xe8	Enter interface mode.
(config-if)#ip address 20.20.20.1/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface xe7.
(config-if)#commit	Commit the transaction.

P - RSVP-TE

(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe7	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe8	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#commit	Commit the transaction.

P - OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 1.1.1.1	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.10.10.0/24 area 0	Define the first network (10.10.10.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 20.20.20.0/24 area 0	Define the second network (20.20.20.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 1.1.1.1/32 area 0	Set the IP address of the loopback interface to 1.1.1.1/32.
(config-router)#commit	Commit the transaction.

PE3 - NSM

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 33.33.33.33/32 secondary	Set the IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#interface ge8	Enter interface mode.
(config-if)#ip address 20.20.20.2/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface ge8.
(config-if)#commit	Commit the transaction.

PE3- RSVP-TE

(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface ge8	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#commit	Commit the transaction.

PE3 - OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 33.33.33.33	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 20.20.20.0/24 area 0	Define the network (20.20.20.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 33.33.33.33/32 area 0	Set the IP address of the loopback interface to 33.33.33.33/32.
(config-router)#commit	Commit the transaction.

PE1 - RSVP-Path

#configure terminal	Enter configure mode.
(config)#rsvp-path PE1_to_PE3_via_P1 mpls	Create an RSVP Path and enter the Path mode.
(config-path)#10.10.10.1 strict	Configure this explicit route path as a strict hop.
(config-path)#20.20.20.2 strict	Configure this explicit route path as a strict hop.
(config-path)#exit	Exit Path mode.
#configure terminal	Enter configure mode.
(config)#rsvp-trunk PE1_to_PE3 ipv4	Create an RSVP trunk and enter the Trunk mode.
(config-trunk)#primary path PE1_to_PE3_via_P1	Configure the trunk to use defined path.
(config-trunk)#from 11.11.11.11	Specify ipv4 source point for the LSP.
(config-trunk)#to 33.33.33.33	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#commit	Commit the transaction.

PE3 - RSVP-Path

#configure terminal	Enter configure mode.
(config)#rsvp-path PE3_to_PE1_via_P1 mpls	Create an RSVP Path and enter the Path mode.
(config-path)#20.20.20.1 strict	Configure this explicit route path as a strict hop.
(config-path)#10.10.10.2 strict	Configure this explicit route path as a strict hop.
(config-path)#exit	Exit Path mode.
#configure terminal	Enter configure mode.
(config)#rsvp-trunk PE3_to_PE1 ipv4	Create an RSVP trunk and enter the Trunk mode.
(config-trunk)#primary path PE3_to_PE1_via_P1	Configure the trunk to use defined path.
(config-trunk)#from 33.33.33.33	Specify the ipv4 source point for LSP
(config-trunk)#to 11.11.11.11	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#commit	Commit the transaction.

PE1 – RSVP-GR

#configure terminal	Enter configure mode.
(config)#router rsvp	Enter the configuration router mode.
(config-router)#neighbor 10.10.10.1	Configure the neighbor ip address.
(config-router)#graceful-restart	Enable the rsvp-gr.
(config-router)#commit	Commit the transaction.

P1 – RSVP-GR

#configure terminal	Enter configure mode.
(config)#router rsvp	Enter the configuration router mode.
(config-router)#neighbor 10.10.10.2	Configure the neighbor ip address.
(config-router)#neighbor 20.20.20.2	Configure the neighbor ip address.
(config-router)#graceful-restart	Enable the rsvp-gr.
(config-router)#commit	Commit the transaction.

PE3 – RSVP-GR

#configure terminal	Enter configure mode.
(config)#router rsvp	Enter the router configuration mode.
(config-router)#neighbor 20.20.20.1	Configure the neighbor ip address.
(config-router)#graceful-restart	Enable the rsvp-gr.
(config-router)#commit	Commit the transaction.

Validation

Verify the RSVP graceful restart on PE1.

```
PE1#show rsvp graceful-restart
Graceful Restart: Enabled
Advertised Restart Time: 200000 msec
Advertised Recovery Time: 360000 msec
Sending Recovery Time: No
```

```
PE1#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
```

```
Egress RSVP:
To      From      Tun-ID  LSP-ID  Type  LSPName      State  Uptime  Rt  Style  Labelin  Labelout
11.11.11.11  33.33.33.33  5001    2201    PRI   PE1_to_PE3 ipv4s  UP     00:54:57  1 1  SE     3        -

Total 5 displayed, Up 5, Down 0.
```

Verify after performing RSVP graceful restart on PE1

```
7038-PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport, (e) - FTN is ECMP
```

FTN-ECMP LDP: **Disabled**

```
Code  FEC      FTN-ID  Nhlf-ID  Tunnel-id  Pri  LSP-Type  Out-Label  Out-Intf  ELC  Nexthop
L>   1.1.1.1/32      3        4        -        Yes  LSP_DEFAULT  3          xe7        No   10.10.10.1
R(t)> p 33.33.33.33/32  20       81       5001      Yes  LSP_DEFAULT  26881      xe7        Yes p 10.10.10.1
```

CHAPTER 5 RSVP Detour Over Ring Topology

Overview

In OcNOS, this feature allows the detour formation in the ring topology to enhance the routing experience. The detour formation is a local protection mechanism to reroute the data traffic when a failure or congestion occurs in the primary Label Switched Path (LSP). In Multiprotocol Label Switching (MPLS), the primary LSP is the default path through which the data travels from the source to the destination node.

Feature Characteristics

This feature allows detour to take the upstream path of protected LSP, allowing a detour based protection in a ring topology. The upstream path of the protected LSP is the section of the network that precedes the PLR node in the network. This feature works for both path and sender-template method of detour formation. For the inter-op solutions that do not support the sender-template method, use the path method of detour formation.

In the below diagram, the data traffic path highlighted in green dots is the primary LSP. The link shown with the red cross is locally protected at the Point of Local Repair (PLR) node. A PLR node is a network device that reacts and takes action when a link fails. For continued data traffic flow, detour occurs through the red dotted line. Detour in MPLS is an alternate path used when the primary LSP encounters disruption or congestion.

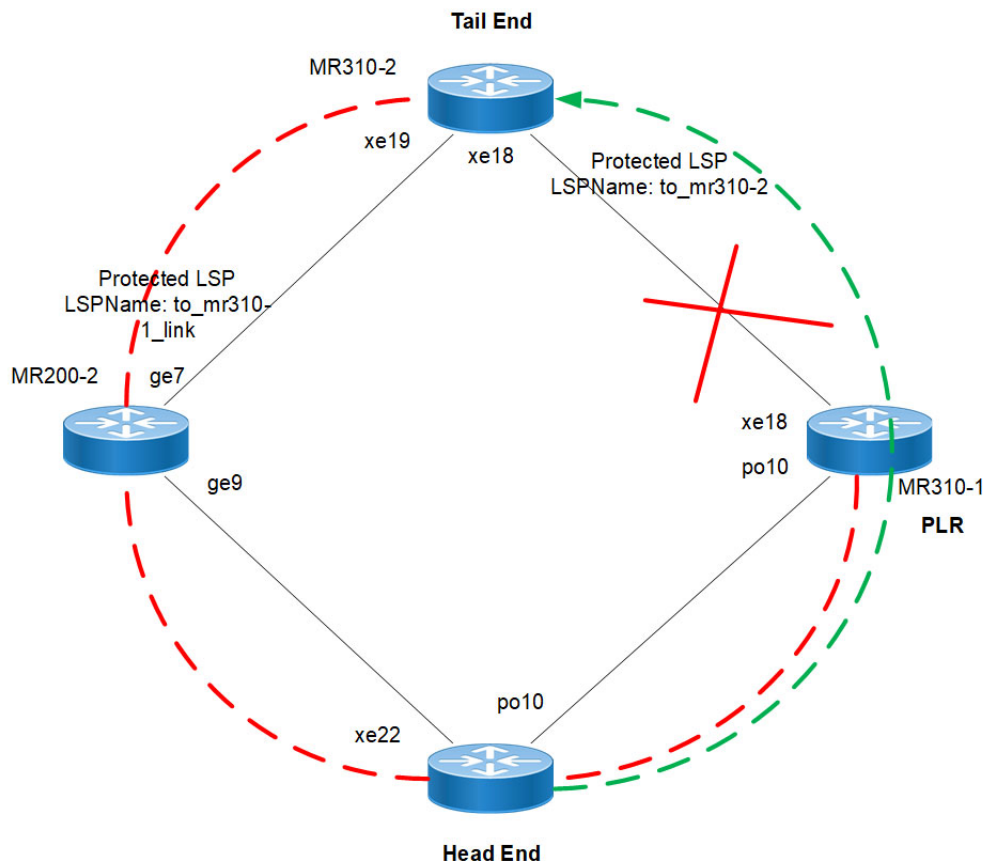


Figure 5-1: RSVP-TE FRR failover ring topology Feature Characteristics

Benefits

This feature helps detour the data traffic when there is a link or node failure, keeping the data traffic loss to a minimum (less than 50ms when BFD negotiated for fastest detection).

Prerequisite

Before the detour configuration in a ring topology, configure the RSVP tunnel with fast reroute protection of the one-to-one method.

For more information, refer to the [Fast Reroute Configuration \(one-to-one method\)](#) section of the [RSVP-TE Configuration](#) chapter in the *OcNOS Multi-Protocol Label Switching Guide*.

Configuration

This section shows the configuration procedure to create a detour in the ring topology.

Topology

Configure the primary LSP in the below ring topology from the head end to the tail end.

For example, consider PE1 as the head end and PE2 as the tail end, and the primary LSP is via R1, R2, and R3. In this case, first configure the [Fast Reroute Configuration \(one-to-one method\)](#) on the PE1 and PE2 and then configure the [detour-allow-primary-upstream-path](#) command in all the nodes. For example, if the link between R3 and PE2 is down, the detour follows via primary LSP to reach PE2.

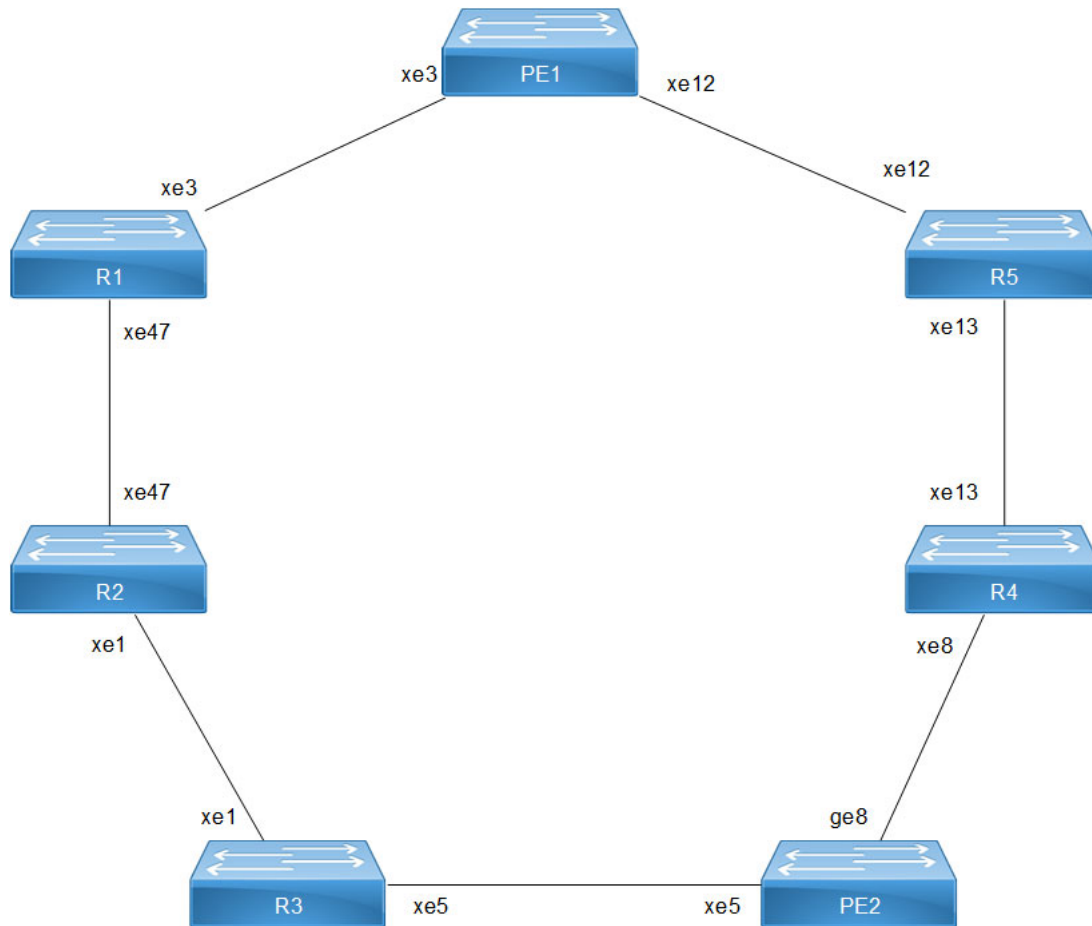


Figure 5-2: RSVP-TE FRR failover ring topology - 1:1 Detour

PE1 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

PE1#configure terminal	Enter configure mode.
PE1(config)#interface xe3	Enter interface mode xe3.
PE1(config-if)#ip address 61.61.61.3/24	Configure IPv4 address 61.61.61.3/24.
PE1(config-if)#label-switching	Configure label switching on xe3.
PE1(config-if)#enable-rsvp	Enable RSVP on xe3.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface xe12	Enter interface mode xe12.
PE1(config-if)#ip address 58.58.58.2/24	Configure IPv4 address 58.58.58.2/24.
PE1(config-if)#label-switching	Configure label switching on xe12.
PE1(config-if)#enable-rsvp	Enable RSVP on xe12.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface lo	Enter loopback interface mode.

PE1(config-if)#ip address 26.26.26.26/32 secondary	Configure IPv4 address 26.26.26.26/32.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#router ospf 100	Enter OSPF router mode.
PE1(config-router)#ospf router-id 26.26.26.26	Assign router ID 26.26.26.26 for OSPF.
PE1(config-router)#network 26.26.26.26/32 area 0.0.0.0	Define network 26.26.26.26/32 under router OSPF.
PE1(config-router)#network 58.58.58.0/24 area 0.0.0.0	Define network 58.58.58.0/24 under router OSPF.
PE1(config-router)#network 61.61.61.0/24 area 0.0.0.0	Define network 61.61.61.0/24 under router OSPF.
PE1(config-router)#exit	Exit router OSPF mode.
PE1(config)#commit	Commit the transaction.
PE1(config)#exit	Exit the configure mode.

PE1 - RSVP Configurations

This section shows:

1. The configuration of detour to take the upstream path of protected LSP.
2. The configuration of the primary LSP and attaching it to the RSVP trunk.
3. The configuration of the FRR.

PE1#configure terminal	Enter configure mode.
PE1(config)#router rsvp	Enable RSVP globally.
PE1(config-router)#detour-allow-primary-upstream-path	Configure this CLI to allow detour to take primary upstream path.
PE1(config-router)#exit	Exit router RSVP mode.
PE1(config)#rsvp-path PE1-PE2-01 mpls	Configure RSVP path PE1-PE2-01 and enter path mode.
PE1(config-path)#61.61.61.2 strict	Configure this explicit route path as a strict hop.
PE1(config-path)#23.23.23.3 strict	Configure this explicit route path as a strict hop.
PE1(config-path)#41.41.41.3 strict	Configure this explicit route path as a strict hop.
PE1(config-path)#56.56.56.3 strict	Configure this explicit route path as a strict hop.
PE1(config-path)#rsvp-trunk TR-PE1-PE2-MP-01 ipv4	Create an RSVP trunk TR-PE1-PE2-MP-01 and enter the trunk mode.
PE1(config-trunk)#primary fast-reroute protection one-to-one	Configure primary fast reroute protection.
PE1(config-trunk)#primary fast-reroute node-protection	Configure node protection.
PE1(config-trunk)#primary path PE1-PE2-01	Configure trunk PE1-PE2-01 to use as the primary LSP.
PE1(config-trunk)#from 26.26.26.26	Assign the source loopback address 26.26.26.26 to the RSVP trunk.
PE1(config-trunk)#to 22.22.22.22	Assign the destination loopback address 22.22.22.22 to the RSVP trunk.
PE1(config-trunk)#exit	Exit router RSVP trunk mode.

PE1 (config) #commit	Commit the transaction.
PE1 (config) #exit	Exit the configure mode.

R1 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

R1#configure terminal	Enter configure mode.
R1 (config) #interface xe3	Enter interface mode xe3.
R1 (config-if) #ip address 61.61.61.2/24	Configure IPv4 address 61.61.61.2/24.
R1 (config-if) #label-switching	Configure label switching on xe3.
R1 (config-if) #enable-rsvp	Enable RSVP on interface xe3.
R1 (config-if) #exit	Exit interface mode.
R1 (config) #interface xe47	Enter interface mode xe47.
R1 (config-if) #ip address 23.23.23.2/24	Configure IPv4 address 23.23.23.2/24.
R1 (config-if) #label-switching	Configure label switching on xe47.
R1 (config-if) #enable-rsvp	Enable RSVP on interface xe47.
R1 (config-if) #exit	Exit interface mode.
R1 (config) #interface lo	Enter loopback interface mode.
R1 (config-if) #ip address 24.24.24.24/32 secondary	Configure IPv4 address 24.24.24.24/32.
R1 (config-if) #exit	Exit interface mode.
R1 (config) #router ospf 100	Enter OSPF router mode.
R1 (config-router) #ospf router-id 24.24.24.24	Assign router-id for OSPF.
R1 (config-router) #network 23.23.23.0/24 area 0.0.0.0	Define network 23.23.23.0/24 under router OSPF.
R1 (config-router) #network 24.24.24.24/32 area 0.0.0.0	Define network 24.24.24.24/32 under router OSPF.
R1 (config-router) #network 61.61.61.0/24 area 0.0.0.0	Define network 61.61.61.0/24 under router OSPF.
R1 (config-router) #exit	Exit router OSPF mode.
R1 (config) #commit	Commit the transaction.
R1 (config) #exit	Exit the configure mode.

R1 - RSVP Configurations

This section shows how to configure the detour to take the upstream path of protected LSP.

R1#configure terminal	Enter configure mode.
R1 (config) #router rsvp	Enable RSVP globally.
R1 (config-router) #detour-allow-primary- upstream-path	Configure this CLI to allow detour to take primary upstream path.
R1 (config-router) #exit	Exit router RSVP mode.
R1 (config) #commit	Commit the transaction.
R1 (config) #exit	Exit the configure mode.

R2 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

R2#configure terminal	Enter configure mode.
R2(config)#interface xe1	Enter interface mode xe1.
R2(config-if)#ip address 41.41.41.2/24	Configure IPv4 address 41.41.41.2/24.
R2(config-if)#label-switching	Configure label switching on xe1.
R2(config-if)#enable-rsvp	Enable RSVP on xe1.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe47	Enter interface mode xe47.
R2(config-if)#ip address 23.23.23.3/24	Configure IPv4 address 23.23.23.3/24.
R2(config-if)#label-switching	Configure label switching on xe47.
R2(config-if)#enable-rsvp	Enable RSVP on xe47.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface lo	Enter loopback interface mode.
R2(config-if)#ip address 88.88.88.88/32 secondary	Configure IPv4 address 88.88.88.88/32.
R2(config-if)#exit	Exit interface mode.
R2(config)#router ospf 100	Enter OSPF router mode.
R2(config-router)#ospf router-id 88.88.88.88	Assign router-id 88.88.88.88 for OSPF.
R2(config-router)#network 23.23.23.0/24 area 0.0.0.0	Define network 23.23.23.0/24 under router OSPF.
R2(config-router)#network 41.41.41.0/24 area 0.0.0.0	Define network 41.41.41.0/24 under router OSPF.
R2(config-router)#network 88.88.88.88/32 area 0.0.0.0	Define network 88.88.88.88/32 under router OSPF.
R2(config-router)#exit	Exit router OSPF mode.
R2(config)#commit	Commit the transaction.
R2(config)#exit	Exit the configure mode.

R2 - RSVP Configurations

This section shows how to configure the detour to take the upstream path of protected LSP.

R2#configure terminal	Enter configure mode.
R2(config)#router rsvp	Enable RSVP globally.
R2(config-router)#detour-allow-primary- upstream-path	Configure this CLI to allow detour to take primary upstream path.
R2(config-router)#exit	Exit router RSVP mode.
R2(config)#commit	Commit the transaction.
R2(config)#exit	Exit the configure mode.

R3 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

R3#configure terminal	Enter configure mode.
R3(config)#interface xe1	Enter interface mode xe1.
R3(config-if)#ip address 41.41.41.3/24	Configure IPv4 address 41.41.41.3/24.
R3(config-if)#label-switching	Configure label switching on xe1.
R3(config-if)#enable-rsvp	Enable RSVP on xe1.
R3(config-if)#exit	Exit interface mode.
R3(config)#interface xe5	Enter interface mode xe5.
R3(config-if)#ip address 56.56.56.2/24	Configure IPv4 address 56.56.56.2/24.
R3(config-if)#label-switching	Configure label switching on xe5.
R3(config-if)#enable-rsvp	Enable RSVP on xe5.
R3(config-if)#exit	Exit interface mode.
R3(config)#interface lo	Enter loopback interface mode.
R3(config-if)#ip address 99.99.99.99/32 secondary	Configure IPv4 address 99.99.99.99/32.
R3(config-if)#exit	Exit interface mode.
R3(config)#router ospf 100	Enter OSPF router mode.
R3(config-router)#ospf router-id 99.99.99.99	Assign router-id for OSPF.
R3(config-router)#network 41.41.41.0/24 area 0.0.0.0	Define network 41.41.41.0/24 under router OSPF.
R3(config-router)#network 56.56.56.0/24 area 0.0.0.0	Define network 56.56.56.0/24 under router OSPF.
R3(config-router)#network 99.99.99.99/32 area 0.0.0.0	Define network 99.99.99.99/32 under router OSPF.
R3(config-router)#exit	Exit router OSPF mode.
R3(config)#commit	Commit the transaction.
R3(config)#exit	Exit the configure mode.

R3 - RSVP Configurations

This section shows how to configure the detour to take the upstream path of protected LSP.

R3#configure terminal	Enter configure mode.
R3(config)#router rsvp	Enable RSVP globally.
R3(config-router)#detour-allow-primary- upstream-path	Configure this CLI to allow detour to take primary upstream path.
R3(config-router)#exit	Exit router RSVP mode.
R3(config)#commit	Commit the transaction.
R3(config)#exit	Exit the configure mode.

R5 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

R5#configure terminal	Enter configure mode.
R5(config)#interface xe1	Enter interface mode 58.58.58.3/24.
R5(config-if)#ip address 58.58.58.3/24	Configure IPv4 address.
R5(config-if)#label-switching	Configure label switching on xe1.
R5(config-if)#enable-rsvp	Enable RSVP on xe1.
R5(config-if)#exit	Exit interface mode.
R5(config)#interface xe13	Enter interface mode xe13.
R5(config-if)#ip address 54.54.54.4/24	Configure IPv4 address 54.54.54.4/24.
R5(config-if)#label-switching	Configure label switching on xe13.
R5(config-if)#enable-rsvp	Enable RSVP on xe13.
R5(config-if)#exit	Exit interface mode.
R5(config)#interface lo	Enter loopback interface mode.
R5(config-if)#ip address 17.17.17.17/32 secondary	Configure IPv4 address 17.17.17.17/32.
R5(config-if)#exit	Exit interface mode.
R5(config)#router ospf 100	Enter OSPF router mode.
R5(config-router)#ospf router-id 17.17.17.17	Assign router-id for OSPF.
R5(config-router)#network 17.17.17.17/32 area 0.0.0.0	Define network 17.17.17.17/32 under router OSPF.
R5(config-router)#network 54.54.54.0/24 area 0.0.0.0	Define network 54.54.54.0/24 under router OSPF.
R5(config-router)#network 58.58.58.0/24 area 0.0.0.0	Define network 58.58.58.0/24 under router OSPF.
R5(config-router)#exit	Exit router OSPF mode.
R5(config)#commit	Commit the transaction.
R5(config)#exit	Exit the configure mode.

R5 - RSVP Configurations

This section shows how to configure the detour to take the upstream path of protected LSP.

R5#configure terminal	Enter configure mode.
R5(config)#router rsvp	Enable RSVP globally.
R5(config-router)#detour-allow-primary- upstream-path	Configure this CLI to allow detour to take primary upstream path
R5(config-router)#exit	Exit router RSVP mode
R5(config)#commit	Commit the transaction.
R5(config)#exit	Exit the configure mode.

R4 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

R4#configure terminal	Enter configure mode.
R4(config)#interface xe13	Enter interface mode xe13.
R4(config-if)#ip address 54.54.54.3/24	Configure IPv4 address 54.54.54.3/24.
R4(config-if)#label-switching	Configure label switching on xe13.
R4(config-if)#enable-rsvp	Enable RSVP on interface xe13.
R4(config-if)#exit	Exit interface mode.
R4(config)#interface xe8	Enter interface mode xe8.
R4(config-if)#ip address 62.62.62.3/24	Configure IPv4 address 62.62.62.3/24.
R4(config-if)#label-switching	Configure label switching on xe8.
R4(config-if)#enable-rsvp	Enable RSVP on xe8.
R4(config-if)#exit	Exit interface mode.
R4(config)#interface lo	Enter loopback interface mode.
R4(config-if)#ip address 48.48.48.48/32 secondary	Configure IPv4 address 48.48.48.48/32.
R4(config-if)#exit	Exit interface mode.
R4(config)#router ospf 100	Enter OSPF router mode.
R4(config-router)#ospf router-id 48.48.48.48	Assign router-id for OSPF.
R4(config-router)#network 48.48.48.48/32 area 0.0.0.0	Define network 48.48.48.48/32 under router OSPF.
R4(config-router)#network 54.54.54.0/24 area 0.0.0.0	Define network 54.54.54.0/24 under router OSPF.
R4(config-router)#network 62.62.62.0/24 area 0.0.0.0	Define network 62.62.62.0/24 under router OSPF.
R4(config-router)#exit	Exit router OSPF mode.
R4(config)#commit	Commit the transaction.
R4(config)#exit	Exit the configure mode.

R4 - RSVP Configurations

This section shows how to configure the detour to take the upstream path of protected LSP.

R4#configure terminal	Enter configure mode.
R4(config)#router rsvp	Enable RSVP globally.
R4(config-router)#detour-allow-primary- upstream-path	Configure this CLI to allow detour to take primary upstream path.
R4(config-router)#exit	Exit router RSVP mode.
R4(config)#commit	Commit the transaction.
R4(config)#exit	Exit the configure mode.

PE2 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

PE2#configure terminal	Enter configure mode.
PE2(config)#interface xe5	Enter interface mode xe5.
PE2(config-if)#ip address 56.56.56.3/24	Configure IPv4 address 56.56.56.3/24.
PE2(config-if)#label-switching	Configure label switching on xe5.
PE2(config-if)#enable-rsvp	Enable RSVP on xe5.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface ge8	Enter interface mode ge8.
PE2(config-if)#ip address 62.62.62.2/24	Configure IPv4 address 62.62.62.2/24.
PE2(config-if)#label-switching	Configure label switching on ge8.
PE2(config-if)#enable-rsvp	Enable RSVP on ge8.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface lo	Enter loopback interface mode.
PE2(config-if)#ip address 22.22.22.22/32 secondary	Configure IPv4 address 22.22.22.22/32.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#router ospf 100	Enter OSPF router mode.
PE2(config-router)#ospf router-id 22.22.22.22	Assign router-id for OSPF.
PE2(config-router)#network 22.22.22.22/32 area 0.0.0.0	Define network 22.22.22.22/32 under router OSPF.
PE2(config-router)#network 56.56.56.0/24 area 0.0.0.0	Define network 56.56.56.0/24 under router OSPF.
PE2(config-router)#network 62.62.62.0/24 area 0.0.0.0	Define network 62.62.62.0/24 under router OSPF.
PE2(config-router)#exit	Exit router OSPF mode.
PE2(config)#commit	Commit the transaction.
PE2(config)#exit	Exit the configure mode.

PE2 - RSVP Configurations

This section shows:

1. The configuration of detour to take the upstream path of protected LSP.
2. The configuration of the primary LSP and attaching it to the RSVP trunk.
3. The configuration of the FRR.

PE2#configure terminal	Enter configure mode.
PE2(config)#router rsvp	Enable RSVP globally.
PE2(config-router)#detour-allow-primary-upstream-path	Configure this CLI to allow detour to take primary upstream path.
PE2(config-router)#exit	Exit router RSVP mode.
PE2(config)#rsvp-path PE2-PE1-01 mpls	Configure RSVP path PE2-PE1-01 and enter path mode.
PE2(config-path)#56.56.56.2 strict	Configure this explicit route path as a strict hop.
PE2(config-path)#41.41.41.2 strict	Configure this explicit route path as a strict hop.

PE2(config-path)#23.23.23.2 strict	Configure this explicit route path as a strict hop.
PE2(config-path)#61.61.61.3 strict	Configure this explicit route path as a strict hop.
PE2(config-router)#exit	Exit path mode.
PE2(config-path)#rsvp-trunk TR-PE2-PE1-MP-01 ipv4	Create an RSVP trunk TR-PE2-PE1-MP-01 and enter the Trunk mode.
PE2(config-trunk)#primary fast-reroute protection one-to-one	Configure primary fast-reroute protection.
PE2(config-trunk)#primary fast-reroute node-protection	Configure node protection.
PE2(config-trunk)#primary path PE2-PE1-01	Configure trunk PE2-PE1-01 to use as the primary LSP.
PE2(config-trunk)#from 22.22.22.22	Assign the source loopback address 22.22.22.22 to the RSVP trunk.
PE2(config-trunk)#to 26.26.26.26	Assign the destination loopback address 26.26.26.26 to the RSVP trunk.
PE2(config-trunk)#exit	Exit router RSVP trunk mode.
PE2(config)#commit	Commit the transaction.
PE2(config)#exit	Exit the configure mode.

Validation

PE1

Below is the validation output of RSVP LSPs from PE1 to PE2 via R1>R2>R3:

```
#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To          From          Tun-ID   LSP-ID   Type   LSPName          State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22 26.26.26.26 5001     2205     PRI    TR-PE1-PE2-MP-01-Primary  UP    02:12:32  1 1 SE    -
52480
22.22.22.22 58.58.58.2  5001     2205     DTR    TR-PE1-PE2-MP-01-Detour   UP    00:34:04  1 2 SE    -
25600
Total 2 displayed, Up 2, Down 0.

Transit RSVP:
To          From          Tun-ID   LSP-ID   Type   LSPName          State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22 61.61.61.2  5001     2205     PRI    TR-PE1-PE2-MP-01-Detour   UP    00:33:19  1 2 SE    25602
25600
Total 1 displayed, Up 1, Down 0.

Egress RSVP:
To          From          Tun-ID   LSP-ID   Type   LSPName          State Uptime    Rt  Style  Labelin
Labelout
26.26.26.26 22.22.22.22 5001     2205     PRI    TR-PE2-PE1-MP-01-Primary  UP    02:12:27  1 1 SE    25601 -
26.26.26.26 62.62.62.2  5001     2205     PRI    TR-PE2-PE1-MP-01-Detour   UP    02:09:08  1 1 SE    25600 -
Total 2 displayed, Up 2, Down 0.
```

Below is the validation output of RSVP ping and trace from PE1 to PE2:

```
#ping mpls rsvp egress 22.22.22.22 detail
Sending 5 MPLS Echos to 22.22.22.22, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errorred TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
```

```

'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

Type 'Ctrl+C' to abort

! seq_num = 1 56.56.56.3 0.91 ms
! seq_num = 2 56.56.56.3 0.54 ms
! seq_num = 3 56.56.56.3 0.48 ms
! seq_num = 4 56.56.56.3 0.47 ms
! seq_num = 5 56.56.56.3 0.50 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.47/0.69/0.91
PE1#
#trace mpls rsvp egress 22.22.22.22 detail
Tracing MPLS Label Switched Path to 22.22.22.22, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

Type 'Ctrl+C' to abort

  0 61.61.61.3 [Labels: 52480]
R 1 61.61.61.2 [Labels: 25600] 0.71 ms
R 2 23.23.23.3 [Labels: 25600] 0.83 ms
R 3 41.41.41.3 [Labels: 25600] 0.88 ms
! 4 56.56.56.3 0.69 ms

```

Below are the outputs from transit nodes R1, R2 and R3 for primary LSP configured:

R1

```

#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To      From      Tun-ID  LSP-ID  Type  LSPName      State Uptime   Rt  Style  Labelin
Labelout
22.22.22.22 61.61.61.2 5001    2205    DTR    TR-PE1-PE2-MP-01-Detour  UP    00:38:43  1 2 SE    -
25602
26.26.26.26 23.23.23.2 5001    2205    DTR    TR-PE2-PE1-MP-01-Detour  UP    00:38:44  1 1 SE    -
25603
Total 2 displayed, Up 2, Down 0.

Transit RSVP:
To      From      Tun-ID  LSP-ID  Type  LSPName      State Uptime   Rt  Style  Labelin
Labelout
22.22.22.22 26.26.26.26 5001    2205    PRI    TR-PE1-PE2-MP-01-Primary  UP    02:17:55  1 1 SE    52480
25600
22.22.22.22 23.23.23.3 5001    2205    PRI    TR-PE1-PE2-MP-01-Detour  UP    00:37:58  1 2 SE    52482
25602
26.26.26.26 22.22.22.22 5001    2205    PRI    TR-PE2-PE1-MP-01-Primary  UP    02:17:50  1 1 SE    52481
25601
Total 3 displayed, Up 3, Down 0.

```

R2

```

#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:

```

To Labelout	From	Tun-ID	LSP-ID	Type	LSPName	State	Uptime	Rt	Style	Labelin
22.22.22.22 52482	23.23.23.3	5001	2205	DTR	TR-PE1-PE2-MP-01-Detour	UP	00:38:07	1 2	SE	-
26.26.26.26 25602	41.41.41.2	5001	2205	DTR	TR-PE2-PE1-MP-01-Detour	UP	00:39:00	1 2	SE	-

Total 2 displayed, Up 2, Down 0.

Transit RSVP:

To Labelout	From	Tun-ID	LSP-ID	Type	LSPName	State	Uptime	Rt	Style	Labelin
22.22.22.22 25600	26.26.26.26	5001	2205	PRI	TR-PE1-PE2-MP-01-Primary	UP	02:18:05	1 1	SE	25600
22.22.22.22 52482	41.41.41.3	5001	2205	PRI	TR-PE1-PE2-MP-01-Detour	UP	00:37:28	1 2	SE	25602
26.26.26.26 52481	22.22.22.22	5001	2205	PRI	TR-PE2-PE1-MP-01-Primary	UP	02:18:00	1 1	SE	25601
26.26.26.26 25602	23.23.23.2	5001	2205	PRI	TR-PE2-PE1-MP-01-Detour	UP	00:38:53	1 2	SE	25603

Total 4 displayed, Up 4, Down 0.

R3

```
#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
```

Ingress RSVP:

To Labelout	From	Tun-ID	LSP-ID	Type	LSPName	State	Uptime	Rt	Style	Labelin
22.22.22.22 25602	41.41.41.3	5001	2205	DTR	TR-PE1-PE2-MP-01-Detour	UP	00:37:31	1 1	SE	-
26.26.26.26 25602	56.56.56.2	5001	2205	DTR	TR-PE2-PE1-MP-01-Detour	UP	00:39:23	1 2	SE	-

Total 2 displayed, Up 2, Down 0.

Transit RSVP:

To Labelout	From	Tun-ID	LSP-ID	Type	LSPName	State	Uptime	Rt	Style	Labelin
22.22.22.22 25600	26.26.26.26	5001	2205	PRI	TR-PE1-PE2-MP-01-Primary	UP	02:18:08	1 1	SE	25600
26.26.26.26 25601	22.22.22.22	5001	2205	PRI	TR-PE2-PE1-MP-01-Primary	UP	02:18:02	1 1	SE	25601
26.26.26.26 25602	41.41.41.2	5001	2205	PRI	TR-PE2-PE1-MP-01-Detour	UP	00:39:03	1 2	SE	25602

Total 3 displayed, Up 3, Down 0.

Below are the outputs from transit nodes R4 and R5 for Detour LSPs formation:

From R4

```
#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
```

Transit RSVP:

To Labelout	From	Tun-ID	LSP-ID	Type	LSPName	State	Uptime	Rt	Style	Labelin
22.22.22.22 25601	58.58.58.2	5001	2205	PRI	TR-PE1-PE2-MP-01-Detour	UP	02:14:52	1 1	SE	25600
26.26.26.26 25601	62.62.62.2	5001	2205	PRI	TR-PE2-PE1-MP-01-Detour	UP	00:39:49	1 1	SE	25601

Total 2 displayed, Up 2, Down 0.

From R5

```
#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
```

Transit RSVP:

To Labelout	From	Tun-ID	LSP-ID	Type	LSPName	State	Uptime	Rt	Style	Labelin
22.22.22.22 25600	58.58.58.2	5001	2205	PRI	TR-PE1-PE2-MP-01-Detour	UP	00:39:45	1 1	SE	25600
26.26.26.26 25600	62.62.62.2	5001	2205	PRI	TR-PE2-PE1-MP-01-Detour	UP	02:14:48	1 1	SE	25601

Total 2 displayed, Up 2, Down 0.

Now, shutting down one of the interfaces on Primary LSP path and check RSVP tunnel outputs on PE1 and PE2

Shutdown interface xe47 connected between R1 and R2:

#configure terminal	Enter Configure mode.
(config)#interface xe47	Enter interface mode.
(config-router)#shutdown	Administratively bring the interface down.
(config-router)#exit	Exit router RSVP mode

Below is the validation output of RSVP LSPs from PE1 to PE2 after admin shutting one of the interfaces on primary LSP path:

```
#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To Labelout      From      Tun-ID  LSP-ID  Type  LSPName      State Uptime    Rt  Style  Labelin
22.22.22.22      26.26.26.26  5001    2205    PRI    TR-PE1-PE2-MP-01-Primary  UP*   02:32:40   1 1  SE    -
52480
22.22.22.22      26.26.26.26  5001    2201    PRI    TR-PE1-PE2-MP-01-Primary  DN    N/A        0 0  SE    -
22.22.22.22      58.58.58.2   5001    2205    DTR    TR-PE1-PE2-MP-01-Detour   UP    00:54:12   1 2  SE    -
25600
Total 3 displayed, Up 2, Down 1.

Transit RSVP:
To Labelout      From      Tun-ID  LSP-ID  Type  LSPName      State Uptime    Rt  Style  Labelin
22.22.22.22      61.61.61.2   5001    2205    PRI    TR-PE1-PE2-MP-01-Detour   UP    00:53:27   1 2  SE    25602
25600
Total 1 displayed, Up 1, Down 0.
```

Below is the validation output of RSVP ping and trace from PE1 to PE2 after shutting one of the interfaces on primary LSP path:

```
Egress RSVP:
To Labelout      From      Tun-ID  LSP-ID  Type  LSPName      State Uptime    Rt  Style  Labelin
26.26.26.26      62.62.62.2   5001    2205    PRI    TR-PE2-PE1-MP-01-Detour   UP    02:29:16   1 1  SE    25600
Total 1 displayed, Up 1, Down 0.

#ping mpls rsvp egress 22.22.22.22 detail
Sending 5 MPLS Echos to 22.22.22.22, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

Type 'Ctrl+C' to abort

! seq_num = 1 62.62.62.2 0.69 ms
! seq_num = 2 62.62.62.2 0.54 ms
! seq_num = 3 62.62.62.2 0.56 ms
```

```
! seq_num = 4 62.62.62.2 0.49 ms
! seq_num = 5 62.62.62.2 0.51 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.49/0.59/0.69
#trace mpls rsvp egress 22.22.22.22 detail
Tracing MPLS Label Switched Path to 22.22.22.22, timeout is 5 seconds
```

Codes:

```
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
```

Type 'Ctrl+C' to abort

```
0 61.61.61.3 [Labels: 52480]
R 1 61.61.61.2 [Labels: 25602] 0.72 ms
R 2 61.61.61.3 [Labels: 25600] 0.67 ms
R 3 58.58.58.3 [Labels: 25600] 0.80 ms
R 4 54.54.54.3 [Labels: 25601] 0.80 ms
! 5 62.62.62.2 0.50 ms
```

Below is the validation output of RSVP LSPs from PE2 to PE1 after admin shutting one of the interfaces on primary LSP path:

#show rsvp session

```
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
```

Ingress RSVP:

To Labelout	From	Tun-ID	LSP-ID	Type	LSPName	State	Uptime	Rt	Style	Labelin
26.26.26.26 25601	22.22.22.22	5001	2205	PRI	TR-PE2-PE1-MP-01-Primary	UP*	02:36:19	1 1	SE	-
26.26.26.26 25601	22.22.22.22	5001	2201	PRI	TR-PE2-PE1-MP-01-Primary	DN	N/A	0 0	SE	-
26.26.26.26 25601	62.62.62.2	5001	2205	DTR	TR-PE2-PE1-MP-01-Detour	UP	00:57:57	1 2	SE	-

Total 3 displayed, Up 2, Down 1.

Transit RSVP:

To Labelout	From	Tun-ID	LSP-ID	Type	LSPName	State	Uptime	Rt	Style	Labelin
26.26.26.26 25601	56.56.56.2	5001	2205	PRI	TR-PE2-PE1-MP-01-Detour	UP	00:57:40	1 2	SE	25602

Total 1 displayed, Up 1, Down 0.

Egress RSVP:

To Labelout	From	Tun-ID	LSP-ID	Type	LSPName	State	Uptime	Rt	Style	Labelin
22.22.22.22	58.58.58.2	5001	2205	PRI	TR-PE1-PE2-MP-01-Detour	UP	02:33:00	1 1	SE	25601

Total 1 displayed, Up 1, Down 0.

Below is the validation output of RSVP ping and trace from PE2 to PE1 after shutting one of the interfaces on primary LSP path:

```
#ping mpls rsvp egress 26.26.26.26 detail
Sending 5 MPLS Echos to 26.26.26.26, timeout is 5 seconds
```

Codes:

```
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
```

Type 'Ctrl+C' to abort

```
! seq_num = 1 58.58.58.2 0.80 ms
! seq_num = 2 58.58.58.2 0.59 ms
! seq_num = 3 58.58.58.2 0.47 ms
! seq_num = 4 58.58.58.2 0.49 ms
! seq_num = 5 58.58.58.2 0.54 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.47/0.63/0.80
#trace mpls rsvp egress 26.26.26.26 detail
Tracing MPLS Label Switched Path to 26.26.26.26, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

Type 'Ctrl+C' to abort

  0 56.56.56.3 [Labels: 25601]
R 1 56.56.56.2 [Labels: 25601] 1.01 ms
R 2 41.41.41.2 [Labels: 25602] 0.95 ms
R 3 41.41.41.3 [Labels: 25602] 0.62 ms
R 4 56.56.56.3 [Labels: 25601] 0.79 ms
R 5 62.62.62.3 [Labels: 25601] 0.67 ms
R 6 54.54.54.4 [Labels: 25600] 0.57 ms
! 7 58.58.58.2 0.50 ms
```

Implementation Examples

To implement detour based protection in a ring topology, use the command [detour-allow-primary-upstream-path](#) that allows the detour formation to consider the upstream path of protected LSP. This is only applicable in ring topology.

New CLI Commands

detour-allow-primary-upstream-path

Use this command to ensure detour formation to consider the upstream path of protected LSPs. This is a deviation to RFC 4090 section 6.2 recommendation (<https://datatracker.ietf.org/doc/html/rfc4090>). This command is intended to be used in special cases where detour protection is required on ring topology if no alternate path is available.

Use the no parameter with this command to bypass the upstream path to the protected LSP when choosing a detour path.

Note: This command is intended to be used in ring topology if detour support is required at the cost of resource and link bandwidth. This command is not recommended to be configured otherwise.

Command Syntax

```
detour-allow-primary-upstream-path
no detour-allow-primary-upstream-path
```

Parameters

None

Default

By default, detour formation excludes the protected LSP upstream path as per RFC 4090 section 6.2 recommendations.

Command Mode

Router mode

Applicability

This command was introduced in OcNOS version 6.4.1.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#detour-allow-primary-upstream-path
(config-router)#commit
(config-router)#no detour-allow-primary-upstream-path
(config-router)#commit
```

Abbreviations

The following are some key abbreviations and their meanings relevant to this document:

Acronym	Description
FRR	Fast Reroute
LSP	Label Switched Path
OSPF	Open Shortest Path First
PLR	Point of Local Repair

Glossary

The following provides definitions for key terms used throughout this document:

Detour formation in the ring topology	The detour formation in the ring topology is a mechanism to reroute the data traffic over the backup path when a failure or congestion occurs in the primary Label Switched Path (LSP).
PLR node	A PLR node is a network device that reacts and takes action when a link fails.
Primary LSP	The primary LSP is the default path of the forwarding data packets from the source device to the destination device.
Protected LSP	A protected LSP is a primary LSP with a backup path in an MPLS network. When there is an issue or a failure in the primary LSP, the traffic is rerouted through the backup path, protecting the primary LSP.

RSVP Tunnel	RSVP tunnels are logical paths through which data traffic traverses in an IP network.
Upstream path of the protected LSP	The upstream path of the protected LSP is the section of the network that precedes the PLR node in the network.

CHAPTER 6 RSVP-TE Dynamic Facility Backup LSP (RSVP Auto Bypass)

Overview

Resource Reservation Protocol (RSVP) auto bypass is a subset of the Facility Backup feature, designed to enhance fast-reroute protection. The facility backup feature operates by establishing bypass tunnels for protected sessions at each PLR node, serving as a local safeguard for sessions on every Point of Local Repair (PLR). Configuring bypass tunnels manually on each PLR, particularly in larger topologies, presented challenges in configuration management. The RSVP auto bypass functionality ensures to dynamically create bypass tunnels when feature enabled in PLR nodes and the sessions come up in PLR requesting facility backup protection.

Feature Characteristics

The RSVP auto bypass operates in conjunction with manual bypass tunnels, and if both manual and auto bypass offer the same level of protection as requested, the manual bypass takes precedence. Auto bypass tunnels, which do not serve any session, have a finite lifetime and are deleted if they remain unused.

Benefits

RSVP auto bypass contributes to a more automated, efficient, and manageable facility backup protection mechanism in RSVP-enabled networks.

Prerequisites

Ensure the following prerequisites are met before configuring RSVP Auto Bypass functionality:

Define Interfaces and Loopback Addresses

Configure Layer 2 interfaces, such as port channel interfaces (e.g., po1), and assign specific IP addresses for proper identification, and routing. Additionally, assign loopback IP addresses to establish essential points of connectivity. These configurations establish the efficient network routing and communication.

```
!  
interface lo  
  ip address 127.0.0.1/8  
  ip address 135.1.1.27/32 secondary  
  ipv6 address ::1/128  
!  
interface po6  
  ip address 1.1.2.2/30  
!  
interface xe6  
  channel-group 6 mode active  
!
```

Configure IGP for Dynamic Routing

Enable ISIS to facilitate dynamic routing on all nodes within the network. Define ISIS router instances to match loopback IP addresses and add network segments to ISIS areas for proper route distribution. Set up neighbor relationships using loopback IP addresses, ensuring efficient route advertisement and convergence for optimal network performance.

ISIS Configuration

```
!  
router isis 1  
  is-type level-2-only  
  metric-style wide  
  mpls traffic-eng router-id 135.1.1.27  
  mpls traffic-eng level-2  
  capability cspf  
  dynamic-hostname  
  fast-reroute ti-lfa level-2 proto ipv4  
  net 49.0000.0000.0027.00  
  passive-interface lo  
!  
interface po6  
  isis network point-to-point  
  ip router isis 1  
!
```

OSPF Configuration

```
!  
router ospf 100  
  ospf router-id 135.1.1.27  
  network 135.1.1.27/32 area 0.0.0.0  
  network 1.1.5.1/24 area 0.0.0.0  
  network 1.1.1.1/24 area 0.0.0.0  
!
```

Configure RSVP for Efficient Network Operation

Enable Resource Reservation Protocol (RSVP) on all nodes to optimize traffic routing and quality of service. RSVP reserves network resources along specified paths to enhance network performance and reliability.

```
!  
router rsvp  
!  
interface xel  
  label-switching  
  enable-rsvp  
!
```

Configure the RSVP Primary Path and Trunk

Establish a trunk on edge routers participating in label-switching using defined path.

```
!  
rsvp-path PE1-PE4-1 mpls
```

```

1.1.1.2 strict
1.1.2.1 strict
1.1.6.1 strict
!
rsvp-trunk PE1-PE4-1 ipv4
primary fast-reroute protection facility
primary fast-reroute node-protection
primary path PE1-PE4-1
from 135.1.1.27
to 135.1.1.44
!
```

Configuration for RSVP Auto Bypass

This section shows the configuration of the various nodes within the topology to set up a RSVP-Auto bypass tunnels.

Topology

The sample topology includes Edge Nodes (PE1, PE2) and core Nodes (P1, P3 and P4). As per sample configurations, Primary path is defined via PE1-P1-P3-PE2 using strict hops and auto bypass tunnel creation is formed on PE1.



Figure 6-3: RSVP-Auto Bypass Configuration

Before configuring RSVP-Auto bypass tunnels, meet all [Prerequisites](#) for the following nodes:

- Edge nodes: PE1 and PE2
- Core nodes: P1, P3, and P4

Auto bypass feature helps in automatically forming bypass tunnels and protecting the facility backup protection requested tunnels.

Configuring RSVP Auto Bypass

Configure RSVP Auto bypass tunnels on PE1 router as follows:

1. Configure auto-bypass under router rsvp.

```
(config)#router rsvp  
(config-router)# auto-bypass
```
2. Enable Auto bypass globally.

```
(config-auto-bypass)# enable
```
3. Modify protection capability attribute for best-effort type bypasses.

```
(config-auto-bypass)# attributes best-effort  
(config-auto-bypass-attr)#protection-capability node
```
4. Modify other auto bypass attributes for best-effort type bypasses.

Note: Auto bypass re-optimization uses the global command to set the re-optimization timer.

```
(config-auto-bypass-attr)# reoptimize
```

5. Configure inactivity timer globally for automatically created bypass tunnels.

Note: The default value for the inactivity-timer is 60 minutes. The minimum timer is 1 and maximum timer is 240.

```
(config-auto-bypass)# inactivity-timer 5
```

Configure RSVP Auto bypass tunnels on P1, P3, P4, PE2 router as follows:

1. Configure auto-bypass under router rsvp.

```
(config)#router rsvp  
(config-router)# auto-bypass
```
2. Enable Auto bypass globally.

```
(config-auto-bypass)# enable
```
3. Modify protection capability attribute for best-effort type bypasses.

```
(config-auto-bypass)# attributes best-effort  
(config-auto-bypass-attr)#protection-capability link
```
4. Modify other auto bypass attributes for best-effort type bypasses.

Note: Auto bypass re-optimization shall use the global command to set the re-optimization timer.

```
(config-auto-bypass-attr)# reoptimize
```

5. Configure inactivity timer globally for automatically created bypass tunnels.

Note: The default value for the inactivity-timer is 60 minutes. The minimum timer is 1 and maximum timer is 240.

```
(config-auto-bypass)# inactivity-timer 5
```

Snippet configuration on PE1 router is as follows:

```

!
router rsvp
  auto-bypass
  attributes best-effort
  protection-capability node
  reoptimize
  exit
  inactivity-timer 5
  enable
  exit
!

```

Snippet configuration on P1, P3, and P4 router is as follows:

```

#show running-config
!
router rsvp
  auto-bypass
  attributes best-effort
  protection-capability link
  reoptimize
  exit
  enable
  exit
!

```

Validation

Verify all sessions including auto bypass sessions summary information:

Bypass name will have a character B or D. BL for Link protection and BN is for Node protection.

PE1#show rsvp session

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass

State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary

* indicates the session is active with local repair at one or more nodes

(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:

To	From	Tun-ID	LSP-ID	Type	LSPName
State Uptime	Rt Style	Labelin	Labelout		
135.1.1.43	135.1.1.27	5001	2203	BPS	BN-135.1.1.42-135.1.1.43-Bypass
UP 00:02:46	1 1 SE -	25604			
135.1.1.44	135.1.1.27	5002	2202	PRI	PE1-PE4-1-Primary
00:13:21	1 1 SE -	25600			UP

Total 2 displayed, Up 2, Down 0.

Transit RSVP:

To	From	Tun-ID	LSP-ID	Type	LSPName
State Uptime	Rt Style	Labelin	Labelout		

```

135.1.1.43      135.1.1.42      5001      2201      PRI      BL-1.1.2.1-135.1.1.43-Bypass
UP      00:10:11      1 1 SE      25601      25600
135.1.1.42      135.1.1.43      5002      2202      PRI      BL-1.1.2.2-135.1.1.42-Bypass
UP      00:10:00      1 1 SE      25602      3
Total 2 displayed, Up 2, Down 0.

```

Egress RSVP:

```

To      From      Tun-ID      LSP-ID      Type      LSPName
State Uptime      Rt  Style  Labelin  Labelout
135.1.1.27      135.1.1.44      5001      2201      PRI      Pe4-Pe1-Primary      UP
00:13:15      1 1 SE      25600      -
135.1.1.27      135.1.1.42      5002      2202      PRI      BL-1.1.1.1-135.1.1.27-Bypass
UP      00:10:00      1 1 SE      3      -

```

PE2#show rsvp session

```

Type   : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State  : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

```

Ingress RSVP:

```

To      From      Tun-ID      LSP-ID      Type      LSPName
State Uptime      Rt  Style  Labelin  Labelout
135.1.1.27      135.1.1.44      5001      2201      PRI      Pe4-Pe1-Primary      UP
00:16:18      1 1 SE      -      25601
135.1.1.43      135.1.1.44      5002      2202      BPS      BL-1.1.6.2-135.1.1.43-Bypass
UP      N/A      0 0 SE      -      -
Total 2 displayed, Up 1, Down 1.

```

Egress RSVP:

```

To      From      Tun-ID      LSP-ID      Type      LSPName
State Uptime      Rt  Style  Labelin  Labelout
135.1.1.44      135.1.1.27      5002      2202      PRI      PE1-PE4-1-Primary      UP
00:16:24      1 1 SE      25600      -
Total 1 displayed, Up 1, Down 0.

```

Verify all sessions including auto bypass sessions detailed information:

PE1#show rsvp session detail

Egress

135.1.1.27

```

From: 135.1.1.44, LSPstate: Up, LSPname: Pe4-Pe1-Primary
Egress FSM state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: facility
Fast-Reroute bandwidth : 0
Protection type desired: Link
Fast-Reroute Hop limit: 255

```

Fast-Reroute Setup priority: 7, Hold priority: 0
Label in: 25600, Label out: -,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 135.1.1.44
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 1.1.1.2, xe1
Path lifetime: 157 seconds (due in 140 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 24093 seconds)
RRO re-use as ERO: Disabled
Label Recording: Enabled
Admin Groups: none
Received Explicit Route Detail :
1.1.1.1/32 strict
Record route:

IP Address Label

1.1.6.1 25601
1.1.2.1 25601
1.1.1.2 25600
<self>
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Recorded Time : N/A
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Ingress (Bypass)
135.1.1.43
From: 135.1.1.27, LSPstate: Up, LSPname: BN-135.1.1.42-135.1.1.43-Bypass
Ingress FSM state: Operational
Establishment Time: 0s 11ms
Setup priority: 7, Hold priority: 0, HOP limit: 255
Auto-bypass Info: Exclude-Node 135.1.1.42, Egress 135.1.1.43, Cspf ISIS
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
LSP Re-Optimization: Enabled, Re-Optimization Timer: 1 minutes, Cspf Client: ISIS
IGP-Shortcut: Disabled, LSP metric: 20
LSP Protection: None
Bypass trunk bandwidth type: Best-effort
Label in: -, Label out: 25604,
Tspec rate: 0, Fspec rate: 0
Policer: Not Configured
Tunnel Id: 5001, LSP Id: 2203, Ext-Tunnel Id: 135.1.1.27
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 1.1.5.2, xe48
Path refresh: 30 seconds (RR enabled) (due in 29821 seconds)

```
Resv lifetime: 157 seconds (due in 147 seconds)
Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Configured Path: none
Exclude Node: 135.1.1.42
Session Explicit Route Detail :
  1.1.5.2/32 strict
  1.1.4.1/32 strict
Record route:
-----
IP Address          Label
-----
<self>
1.1.5.2
1.1.4.1
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
Recorded Time : N/A
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Last Signaled Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Total LSP protected : 1, Bandwidth in use : 0
Transit
135.1.1.43
  From: 135.1.1.42, LSPstate: Up, LSPname: BL-1.1.2.1-135.1.1.43-Bypass
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: 25601, Label out: 25600,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 135.1.1.42
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 1.1.5.2, xe48 Upstream: 1.1.1.2, xe1
  Path refresh: 30 seconds (RR enabled) (due in 29384 seconds)
  Path lifetime: 157 seconds (due in 140 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 32128 seconds)
  Resv lifetime: 157 seconds (due in 147 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Received Explicit Route Detail :
    1.1.1.1/32 strict
```

```
1.1.5.2/32 strict
1.1.4.1/32 strict
Session Explicit Route Detail :
  1.1.5.2/32 strict
  1.1.4.1/32 strict
Record route:
-----
IP Address          Label
-----
1.1.1.2
<self>
1.1.5.2
1.1.4.1
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type:  ELSP_CONFIG
CLASS      DSCP_value      EXP_value
Recorded Time : N/A
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Egress
135.1.1.27
From: 135.1.1.42, LSPstate: Up, LSPname: BL-1.1.1.1-135.1.1.27-Bypass
Egress FSM state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in:          3, Label out: -,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 135.1.1.42
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 1.1.5.2, xe48
Path lifetime: 157 seconds (due in 147 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 21158 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Received Explicit Route Detail :
  1.1.5.1/32 strict
Record route:
-----
IP Address          Label
-----
1.1.3.2
1.1.5.2
<self>
Style: Shared Explicit Filter
```

Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Recorded Time : N/A
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Transit
135.1.1.42
From: 135.1.1.43, LSPstate: Up, LSPname: BL-1.1.2.2-135.1.1.42-Bypass
Transit upstream state: Operational, downstream state: Operational
Setup priority: 2, Hold priority: 2
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 25602, Label out: 3,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 135.1.1.43
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 1.1.1.2, xe1 Upstream: 1.1.5.2, xe48
Path refresh: 30 seconds (RR enabled) (due in 29400 seconds)
Path lifetime: 157 seconds (due in 147 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 40649 seconds)
Resv lifetime: 157 seconds (due in 140 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Received Explicit Route Detail :
1.1.5.1/32 strict
1.1.1.2/32 strict
Session Explicit Route Detail :
1.1.1.2/32 strict
Record route:

IP Address Label

1.1.4.1
1.1.5.2
<self>
1.1.1.2
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Recorded Time : N/A
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A

```
Trunk Type: mpls
Ingress (Primary)
135.1.1.44
  From: 135.1.1.27, LSPstate: Up, LSPname: PE1-PE4-1-Primary
  Ingress FSM state: Operational
  Establishment Time: 0s 16ms
  Setup priority: 7, Hold priority: 0, HOP limit: 255
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: ISIS
  IGP-Shortcut: Disabled, LSP metric: 30
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Node
  Fast-Reroute Hop limit: 255
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Bypass trunk: BN-135.1.1.42-135.1.1.43, Merge Point: 1.1.2.1, MP Label: 25600
    Bypass OutLabel: 25604, OutIntf: xe48
    Protection provided -> Type: Node, BW: Best-effort, Match-Code: Perfect-match
  Label in: -, Label out: 25600,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 135.1.1.27
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 1.1.1.2, xe1
  Path refresh: 30 seconds (RR enabled) (due in 29192 seconds)
  Resv refresh: 0 seconds (due in 1 seconds)
  Resv lifetime: 157 seconds (due in 140 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Enabled
  Admin Groups: none
  Configured Path: PE1-PE4-1 (in use)
  Configured Explicit Route Detail :
    1.1.1.2/32 strict
    1.1.2.1/32 strict
    1.1.6.1/32 strict
  Session Explicit Route Detail :
    1.1.1.2/32 strict
    1.1.2.1/32 strict
    1.1.6.1/32 strict
  Record route:
    LP = 1 -> PLR's Downstream link is protected      PU = 1 -> Protection is in use on
PLR
    NP = 1 -> PLR's Downstream neighbor is protected  BP = 1 -> BW protection available
at PLR
-----
IP Address      Label      (LP, PU, NP, BP)
-----
<self>
1.1.1.2         25600      ( 1,  0,  0,  0)
1.1.2.1         25600      ( 0,  0,  0,  0)
```



```

1.1.6.1          25600      ( 0,  0,  0,  0)
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
Recorded Time : N/A
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Last Signaled Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Trunk Type: mpls

```

Verify particular Bypass session detail information:

```

PE1#show rsvp bypass BN-135.1.1.42-135.1.1.43
Ingress (Bypass)
135.1.1.43
  From: 135.1.1.27, LSPstate: Up, LSPname: BN-135.1.1.42-135.1.1.43-Bypass
  Ingress FSM state: Operational
  Establishment Time: 0s 11ms
  Setup priority: 7, Hold priority: 0, HOP limit: 255
  Auto-bypass Info: Exclude-Node 135.1.1.42, Egress 135.1.1.43, Cspf ISIS
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Enabled, Re-Optimization Timer: 1 minutes, Cspf Client: ISIS
  IGP-Shortcut: Disabled, LSP metric: 20
  LSP Protection: None
  Bypass trunk bandwidth type: Best-effort
    Label in: -, Label out: 25604,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2203, Ext-Tunnel Id: 135.1.1.27
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 1.1.5.2, xe48
  Path refresh: 30 seconds (RR enabled) (due in 29807 seconds)
  Resv lifetime: 157 seconds (due in 157 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: none
  Exclude Node: 135.1.1.42
  Session Explicit Route Detail :
    1.1.5.2/32 strict
    1.1.4.1/32 strict
  Record route:
  -----
  IP Address      Label
  -----
  <self>

```

```

1.1.5.2
1.1.4.1
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
Recorded Time : N/A
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Last Signaled Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Total LSP protected : 1, Bandwidth in use : 0

```

Verify using below show command for LSP's Protected by the Bypass tunnel:

```

PE1#show rsvp bypass BN-135.1.1.42-135.1.1.43 protected-lsp-list
Match Code: 0 - Perfect match (all criteria matching), 1 - Bandwidth protection miss, 2
- Node protection miss,
          3 - SRLG protection miss, 4 - Merge point not ideal, 255 - Invalid

```

```

Bypass trunk: BN-135.1.1.42-135.1.1.43
Bypass trunk bandwidth type: best-effort
List of LSP's Protected:
Tunnel-id Lsp-Id   Lsp-Name                Role    Ext_tnl_id    Ingress
Egress      Match-Code Mapped-BW
5002        2202        PE1-PE4-1-Primary      NA      Ingress      135.1.1.27
135.1.1.27  135.1.1.44  0
Total LSP protected : 1
Bandwidth in use : 0

```

Verify using below show command for mpls forwarding-table information:

```

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled
Code  FEC                FTN-ID  Nhlfe-ID  Tunnel-id  Pri  LSP-Type  Out-Label  Out-Intf  ELC  Nexthop
R(b)>  135.1.1.43/32     15      37        5001      Yes  LSP_DEFAULT 25604      xe48      No   1.1.5.2
R(t)>  135.1.1.44/32     9       19        5002      Yes  LSP_DEFAULT 25600      xe1       No   1.1.1.2
R(t)>  135.1.1.44/32     14      38        5002      No   LSP_DEFAULT 25600      xe48      No   135.1.1.43
                                   (via 1.1.5.2, label 25604)

```

(via 1.1.5.2, label 25604)

Shutdown the primary path and verify for node protection functionality:

Shutdown interface between PE1-P1, so that primary path goes Down and backup in use.

```
config)#interface xe1
(config-if)#shutdown
(config-if)#commit
```

Verify auto bypass sessions summary information:

```
PE1#show rsvp session
Type   : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State  : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
        Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To      From      Tun-ID  LSP-ID  Type  LSPName
State Uptime  Rt Style  Labelin Labelout
135.1.1.43 135.1.1.27 5001    2203    BPS   BN-135.1.1.42-135.1.1.43-Bypass
UP      00:06:18 1 3 SE   -       25604
135.1.1.44 135.1.1.27 5002    2202    PRI   PE1-PE4-1-Primary           BU
00:16:53 1 3 SE   -       25600
135.1.1.44 135.1.1.27 5002    2201    PRI   PE1-PE4-1-Primary           DN
N/A      0 0 SE   -       -
Total 3 displayed, Up 2, Down 1.

Egress RSVP:
To      From      Tun-ID  LSP-ID  Type  LSPName
State Uptime  Rt Style  Labelin Labelout
135.1.1.27 135.1.1.44 5001    2201    PRI   Pe4-Pe1-Primary             UP
00:16:47 1 1 SE   25600   -
135.1.1.27 135.1.1.42 5002    2202    PRI   BL-1.1.1.1-135.1.1.27-Bypass
UP      00:13:32 1 1 SE   3       -
Total 2 displayed, Up 2, Down 0.
```

Verify particular Bypass session detail information:

```
PE1#show rsvp bypass BN-135.1.1.42-135.1.1.43
Ingress (Bypass)
135.1.1.43
  From: 135.1.1.27, LSPstate: Up, LSPname: BN-135.1.1.42-135.1.1.43-Bypass
  Ingress FSM state: Operational
  Establishment Time: 0s 11ms
  Setup priority: 7, Hold priority: 0, HOP limit: 255
```

```

Auto-bypass Info: Exclude-Node 135.1.1.42, Egress 135.1.1.43, Cspf ISIS
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
LSP Re-Optimization: Enabled, Re-Optimization Timer: 1 minutes, Cspf Client: ISIS
IGP-Shortcut: Disabled, LSP metric: 20
LSP Protection: None
Bypass trunk bandwidth type: Best-effort
  Label in: -, Label out: 25604,
Tspec rate: 0, Fspec rate: 0
Policer: Not Configured
Tunnel Id: 5001, LSP Id: 2203, Ext-Tunnel Id: 135.1.1.27
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 1.1.5.2, xe48
Path refresh: 30 seconds (RR enabled) (due in 29602 seconds)
Resv lifetime: 157 seconds (due in 155 seconds)
Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Configured Path: none
Exclude Node: 135.1.1.42
Session Explicit Route Detail :
  1.1.5.2/32 strict
  1.1.4.1/32 strict
Record route:
-----
IP Address          Label
-----
<self>
1.1.5.2
1.1.4.1
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
Recorded Time : N/A
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Last Signaled Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Total LSP protected : 1, Bandwidth in use : 0

```

Verify using below show command for MPLS forwarding-table information:

```

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,

```

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
 U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
 (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label
Out-Intf	ELC	Nexthop					
R(b)> xe48	135.1.1.43/32 No	15 1.1.5.2	37	5001	Yes	LSP_DEFAULT	25604
R(t)! xe1	135.1.1.44/32 No	9 1.1.1.2	19	5002	Yes	LSP_DEFAULT	25600
R(t)> xe48	135.1.1.44/32 No	14 135.1.1.43	38	5002	No	LSP_DEFAULT	25600

(via 1.1.5.2, label 25604)

Verify using below show command for LSP's Protected by the Bypass tunnel:

```
PE1#show rsvp bypass BN-135.1.1.42-135.1.1.43 protected-lsp-list
Match Code: 0 - Perfect match (all criteria matching), 1 - Bandwidth protection miss, 2
- Node protection miss,
          3 - SRLG protection miss, 4 - Merge point not ideal, 255 - Invalid
```

```
Bypass trunk: BN-135.1.1.42-135.1.1.43
Bypass trunk bandwidth type: best-effort
```

List of LSP's Protected:

Tunnel-id	Lsp-Id	Lsp-Name	Role	Ext_tnl_id	Ingress
Egress	Match-Code	Mapped-BW			
5002	2202	PE1-PE4-1-Primary		Ingress	135.1.1.27
135.1.1.27	135.1.1.44	0	NA		

Total LSP protected : 1

Bandwidth in use : 0

Auto Bypass and Manual Bypass Co-exists with Perfect Protection

Manual bypass and auto bypass coexist and when manual bypass already providing perfect protection, then manual bypass preferred over auto bypass. auto bypass won't be triggered.

Auto bypass is created when Manual bypass is provided with perfect protection as link

Snippet configuration on PE1 router for Auto-bypass is as follows:

```
#show running-config
!
router rsvp
  auto-bypass
  attributes best-effort
  protection-capability link
  reoptimize
  exit
  inactivity-timer 5
  enable
  exit
!
```

Snippet configuration on PE1 router for Manual-bypass is as follows:

```

!
rsvp-path backup-PE1-P4-P1 mpls
 1.1.5.2 strict
 1.1.3.2 strict
!
rsvp-bypass backup-to-p1
 path backup-PE1-P4-P1
 to 135.1.1.44
!

```

Validation

Verify all sessions including auto bypass sessions summary information:

Manual bypass and auto bypass coexist and when manual bypass already providing perfect protection, auto bypass session goes down when manual bypass exists.

Verify all RSVP sessions information: The output shows only manual bypass session information when Manual bypass and auto bypass coexist and when manual bypass already providing perfect protection.

PE1#show rsvp session

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass

State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary

* indicates the session is active with local repair at one or more nodes

(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:

To	From	Tun-ID	LSP-ID	Type	LSPName	
State Uptime	Rt Style	Labelin	Labelout			
135.1.1.44	135.1.1.27	5001	2205	PRI	PE1-PE4-Primary	UP
00:16:19 1 1 SE	-	25604				
135.1.1.44	135.1.1.27	5002	2206	PRI	PE1-PE4-1-Primary	UP
00:16:21 1 1 SE	-	25602				
135.1.1.44	135.1.1.27	5003	2203	BPS	backup-to-p1-Bypass	
UP 00:05:18 1 1 SE	-	25601				

Total 3 displayed, Up 3, Down 0.

Transit RSVP:

To	From	Tun-ID	LSP-ID	Type	LSPName	
State Uptime	Rt Style	Labelin	Labelout			
135.1.1.28	135.1.1.42	5002	2202	PRI	BL-1.1.9.1-135.1.1.28-Bypass	
UP 00:16:19 1 1 SE	25601	3				

Total 1 displayed, Up 1, Down 0.

Egress RSVP:

To	From	Tun-ID	LSP-ID	Type	LSPName	
State Uptime	Rt Style	Labelin	Labelout			
135.1.1.27	135.1.1.42	5001	2201	PRI	BL-1.1.1.1-135.1.1.27-Bypass	
UP 00:16:37 1 1 SE	3	-				
135.1.1.27	135.1.1.44	5001	2201	PRI	Pe4-Pe1-Primary	UP
00:16:37 1 1 SE	25600	-				

Total 2 displayed, Up 2, Down 0.

Verify using below show command for LSP's Protected by the Bypass tunnel:

```
PE1#show rsvp bypass BN-135.1.1.42-135.1.1.43 protected-lsp-list
Match Code: 0 - Perfect match (all criteria matching), 1 - Bandwidth protection miss, 2
- Node protection miss,
          3 - SRLG protection miss, 4 - Merge point not ideal, 255 - Invalid

Bypass trunk: BN-135.1.1.42-135.1.1.43
Bypass trunk bandwidth type: best-effort
List of LSP's Protected:
```

Tunnel-id	Lsp-Id	Lsp-Name	Role	Ext_tnl_id	Ingress
5001	2205	PE1-PE4-1-Primary		Ingress	135.1.1.27
135.1.1.27		135.1.1.44	2	NA	
5002	2206	PE1-PE4-1-Primary		Ingress	135.1.1.27
135.1.1.27		135.1.1.44	2	NA	

```
Total LSP protected : 1
Bandwidth in use : 0
```

Auto Bypass with Node Protection and Manual Bypass with Link Protection

Snippet configuration on PE1 router for Auto-bypass is as follows:

```
!
router rsvp
  auto-bypass
  attributes best-effort
  protection-capability node
  reoptimize
  exit
  inactivity-timer 5
  enable
  exit
!
```

Snippet configuration on PE1 router for Manual-bypass is as follows:

```
!
rsvp-path backup-PE1-P4-P1 mpls
  1.1.5.2 strict
  1.1.3.2 strict
!
rsvp-bypass backup-to-p1
  path backup-PE1-P4-P1
  to 135.1.1.44
!
```

Validation

Verify all sessions including auto bypass sessions summary information: The output shows that Manual bypass for link protection is UP and auto bypass for node protection is UP and running.

```
PE1#show rsvp session
```

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass

State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary

* indicates the session is active with local repair at one or more nodes

(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:

To	From	Tun-ID	LSP-ID	Type	LSPName	
State Uptime	Rt Style	Labelin	Labelout			
135.1.1.44	135.1.1.27	5001	2205	PRI	PE1-PE4-Primary	UP
00:22:44 1 1 SE	-	25604				
135.1.1.44	135.1.1.27	5002	2206	PRI	PE1-PE4-1-Primary	UP
00:22:46 1 1 SE	-	25602				
135.1.1.44	135.1.1.27	5003	2203	BPS	backup-to-p1-Bypass	
UP 00:11:43 1 1 SE	-	25601				
135.1.1.28	135.1.1.27	5004	2201	BPS	BN-135.1.1.42-135.1.1.28-Bypass	
UP 00:05:17 1 1 SE	-	3				
135.1.1.43	135.1.1.27	5006	2204	BPS	BN-135.1.1.42-135.1.1.43-Bypass	
UP 00:05:17 1 1 SE	-	25602				

Total 5 displayed, Up 5, Down 0.

Transit RSVP:

To	From	Tun-ID	LSP-ID	Type	LSPName
State Uptime	Rt Style	Labelin	Labelout		
135.1.1.28	135.1.1.42	5002	2202	PRI	BL-1.1.9.1-135.1.1.28-Bypass
UP 00:22:44 1 1 SE	25601	3			

Total 1 displayed, Up 1, Down 0.

Egress RSVP:

To	From	Tun-ID	LSP-ID	Type	LSPName
State Uptime	Rt Style	Labelin	Labelout		
135.1.1.27	135.1.1.42	5001	2201	PRI	BL-1.1.1.1-135.1.1.27-Bypass
UP 00:23:02 1 1 SE	3	-			
135.1.1.27	135.1.1.44	5001	2201	PRI	Pe4-Pe1-Primary
UP 00:23:02 1 1 SE	25600	-			

Total 2 displayed, Up 2, Down 0.

Verify using below show command for LSP's Protected by the Bypass tunnels:

```
PE1#sh rsvp bypass protected-lsp-list
```

Match Code: 0 - Perfect match (all criteria matching), 1 - Bandwidth protection miss, 2 - Node protection miss,
3 - SRLG protection miss, 4 - Merge point not ideal, 255 - Invalid

Bypass trunk: backup-to-p1


```
Bypass trunk bandwidth type: best-effort
Total LSP protected : 0
Bandwidth in use : 0
```

```
Bypass trunk: BN-135.1.1.42-135.1.1.43
Bypass trunk bandwidth type: best-effort
```

List of LSP's Protected:

Tunnel-id	Lsp-Id	Lsp-Name	Role	Ext_tnl_id	Ingress
Egress		Match-Code Mapped-BW			
5006	2207	PE1-PE4-1-Primary		Ingress	135.1.1.27
135.1.1.27		135.1.1.44 0	NA		

```
Total LSP protected : 1
Bandwidth in use : 0
```

```
Bypass trunk: BN-135.1.1.42-135.1.1.28
Bypass trunk bandwidth type: best-effort
```

List of LSP's Protected:

Tunnel-id	Lsp-Id	Lsp-Name	Role	Ext_tnl_id	Ingress
Egress		Match-Code Mapped-BW			
5004	2205	PE1-PE4-Primary		Ingress	135.1.1.27
135.1.1.27		135.1.1.44 0	NA		

```
Total LSP protected : 1
Bandwidth in use : 0
```

RSVP Auto Bypass Commands

The RSVP auto bypass introduces the following configuration commands within the Facility Backup commands.

auto-bypass

Use this command to enter a new mode of auto-bypass to configure auto bypass specific commands and enable auto bypass feature.

Use the `no` parameter to auto bypass configurations. When configuration removed at global level, all auto bypass configuration will be removed and all dynamically created bypass tunnels will be deleted.

Command Syntax

```
auto-bypass
no auto-bypass
```

Parameters

None

Default

Disabled

Command Mode

Router mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

This example is for configuring auto bypass:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-router)#exit
(config-router)#no auto-bypass
```

auto-bypass enable

Use this command to enable or disable auto bypass functionality. When this functionality is enabled, sessions requesting facility backup protection will attempt creation of bypass tunnels dynamically, if no satisfying bypass protection is available. If topology supports the formation of dynamically created bypass session, then the sessions will be protected by dynamically created bypass tunnels.

When manual bypass created, which satisfies protection requirement similar to auto bypass tunnels, then manual bypass tunnel gets preference over auto bypass tunnels. However, if auto bypass tunnels provide better protection (based on session request) than manual bypass, then auto bypass tunnels considered for protection over manual bypass tunnels.

Use the `disable` parameter to disable the auto bypass functionality. When this functionality is disabled, all dynamically created bypass tunnels will be deleted.

Command Syntax

```
enable
disable
```

Parameters

None

Default

Disabled

Command Mode

Auto bypass mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

This example is for enabling the auto bypass:

```
#configure terminal
(config)#router rsvp
```

```
(config-router)#auto-bypass
(config-auto-bypass)#enable
(config-auto-bypass)#commit
(config-auto-bypass)#exit
```

This example is for disabling the auto bypass:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#disable
(config-auto-bypass)#commit
(config-auto-bypass)#exit
```

inactivity-timer

Use this command to configure inactivity timer for auto bypass tunnels. When auto bypass tunnels do not protect any session, inactivity timer will decide how long to retain the auto bypass tunnels before deleting them. If auto bypass tunnel starts protecting any session, then inactivity timer will be stopped.

Use the `no` parameter to reset auto bypass inactivity timer to default value.

Command Syntax

```
inactivity-timer <1-240>
no inactivity-timer
```

Parameters

<code>inactivity-timer <1-240></code>	Specifies the RSVP auto bypass inactivity timer in minutes. This timer determines the maximum time that dynamically created auto bypass tunnels can remain inactive before being deleted. The default value is 60 minutes.
---	--

Default

None

Command Mode

Auto bypass mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

This example is for setting the inactivity timer to 5 minutes:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#inactivity-timer 5
(config-auto-bypass)#commit
(config-auto-bypass)#exit
```

attributes

Use this command to configure auto bypass attributes. Currently only best-effort type auto bypass tunnels supported and hence user can modify the attributes of best-effort type auto bypass. This command takes to new mode in which several parameters can be configured. The parameters configured in this mode are applicable to auto bypass sessions of attribute type.

Use the `no` parameter to reset auto bypass attributes of matching type to default values.

Command Syntax

```
attributes best-effort
no attributes best-effort
```

Parameters

<code>best-effort</code>	Specifies the auto bypass attribute configuration for the best-effort type in auto bypass.
--------------------------	--

Default

The initial configuration for best-effort auto bypass attributes is not set, and the internal entities have their default settings.

Command Mode

Auto bypass mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

This example is for configuring auto bypass attributes:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

This example is to reset auto bypass attributes of matching type to default values:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
(config-auto-bypass)#no attributes best-effort
(config-auto-bypass)#commit
(config-auto-bypass)#exit
```

protection-capability

Use this command to set the protection capability attribute for auto bypass. Capability setting decides the types of auto bypass tunnels allowed to be attempted. When capability configured as link, only exclude link type of bypass creation will be attempted and provides protection against only link failure. When capability node is configured, if session requests for node protection, then exclude node type bypass will also be created along with exclude link type bypass and provides the best protection possible. Even when capability configured as node, if session doesn't request for node protection, then node protecting bypass formation will not be attempted.

Use the `no` parameter to reset the attribute to default value which is capability type node.

Command Syntax

```
protection-capability (link | node)
no protection-capability
```

Parameters

<code>link</code>	Specifies the capability for link protection only.
<code>node</code>	Specifies the capability for link and node protection.

Default

The value for protection capability is `node`.

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for setting up the protection capability attribute to `link`:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#protection-capability link
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example to reset the protection capability attribute to default value:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#no protection-capability
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

bandwidth

Use this command to set the bandwidth attribute for auto bypass. Auto bypass sessions of matching attribute type will inherit this bandwidth constraint while requesting for an LSP to CSPF.

Use the `no` parameter to remove bandwidth attribute and auto bypass sessions will not request any bandwidth constraint to form LSP.

Command Syntax

```
bandwidth BANDWIDTH
no bandwidth
```

Parameters

BANDWIDTH	Specifies the bandwidth attribute for auto bypass within the range of 1k to 100g. The default value is zero.
-----------	--

Default

None

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for setting up the bandwidth attribute to 100g:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#bandwidth 100g
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example to reset the bandwidth attribute to default value:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#no bandwidth
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

setup-priority

Use this command to set the setup priority attribute for auto bypass. Auto bypass sessions of matching attribute type will inherit this setup priority constraint while requesting for an LSP to CSPF.

Use the `no` parameter to reset setup priority attribute to default value.

Command Syntax

```
setup-priority <0-7>
no setup-priority
```

Parameters

setup-priority <0-7>	Specifies the attribute for Auto bypass setup priority. The default value for attribute for setup priority is 7.
----------------------	--

Default

None

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.0.

Example

Example for setting up the setup priority attribute to 5.

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass attributes best-effort
(config-auto-bypass-attr)#setup-priority 5
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example to reset the setup priority attribute to default value.

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass attributes best-effort
(config-auto-bypass-attr)#no setup-priority
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

hold-priority

Use this command to set the hold priority attribute for auto bypass. Auto bypass sessions of matching attribute type will inherit this hold priority constraint while requesting for an LSP to CSPF.

Use the `no` parameter to reset hold priority attribute to default value.

Command Syntax

```
hold-priority <0-7>
no hold-priority
```

Parameters

`hold-priority <0-7>` Specifies the attribute for Auto bypass hold priority. The default value is 0.

Default

None

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for setting up the hold priority attribute to 2:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#hold-priority 2
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example to reset the hold priority attribute to default value:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#no hold-priority
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

hop-limit

Use this command to set the hop limit attribute for auto bypass. Auto bypass sessions of matching attribute type will inherit this hop limit constraint while requesting for an LSP to CSPF.

Use the `no` parameter to reset hop limit attribute to default value.

Command Syntax

```
hop-limit <1-255>
no hop-limit
```

Parameters

`hop-limit <1-255>` Specifies the attribute for Auto bypass hop limit. The default value is 255.

Default

None

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for setting up the hop limit attribute to 5:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#hop-limit 5
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example to reset the hop limit attribute to default value:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#no hop-limit
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

reoptimize

Use this command to set the re-optimization attribute for auto bypass. Auto bypass sessions of matching attribute type will be enabled for re-optimization when the attribute is configured.

Use the `no` parameter to disable re-optimization for auto bypass.

Command Syntax

```
reoptimize
no reoptimize
```

Parameters

None

Default

The auto bypass re-optimization is disabled.

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for enabling the re-optimization attribute:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#reoptimize
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example for disabling the re-optimization attribute:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#no reoptimize
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

exclude-address

Use this command to configure exclude address attribute for auto bypass. Auto bypass sessions of matching attribute type will inherit this explicit exclude address constraint while requesting for an LSP to CSPF. CSPF will provide the auto bypass path excluding the implicit exclude address and the configured exclude addresses.

Note: When link address added for exclusion, next-hop address on the link must be configured to exclude the link in forward direction and also if the link must be excluded in both direction, then both link address and the next-hop address must be added to exclude address list. For node address exclusion, it is recommended to configure the loopback address which is part of routing.

Use the `no` parameter to remove the exclude address constraint.

Command Syntax

```
exclude-address (link | node) A.B.C.D
no exclude-address (link | node) A.B.C.D
```

Parameters

<code>link A.B.C.D</code>	Specifies the exclude address of type link.
<code>node A.B.C.D</code>	Specifies the exclude address of node link.

Default

Auto bypass will only have an implicit exclude address, which is the immediate link or node of the protected session. No additional exclude address constraints are applied.

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for configuring exclude address attribute to link 10.1.1.2:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#exclude-address link 10.1.1.2
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example for configuring exclude address attribute to node 2.2.2.2:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#exclude-address node 2.2.2.2
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example to remove the exclude address constraint from link 10.1.1.2:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#no exclude-address link 10.1.1.2
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Show Commands - RSVP Auto Bypass

show rsvp router-id-table

Use this command to display the mapping of link addresses to router IDs maintained by the RSVP module to reduce the number of CSPF query.

Note: This command can display no information even when auto bypass sessions are active but that is just an indication that RSVP module doesn't hold the CSPF data locally and will collect data from CSPF when required.

Command Syntax

```
show rsvp router-id-table
```

Parameters

None

Command Mode

Exec and Privileged exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for viewing RSVP router ID table:

```
#show rsvp router-id-table
Link Address      Router ID      Query Status   CSPF Client    Refcnt
-----+-----+-----+-----+-----
23.1.1.3          3.3.3.3       COMPLETE      ISIS           3
```

show rsvp srlg-group

This command displays mapping of unique ID value used in auto bypass name to the SRLG group when srlg-disjoint is configured.

Note that, only OSPF CSPF provides SRLG protection. SRLG configuration not recommended to be configured when CSPF is ISIS.

Command Syntax

```
show rsvp srlg-group
```

Parameters

None

Command Mode

Exec and Privileged exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for viewing SRLG group:

```
#show rsvp srlg-group
Group-ID  Refcnt  SRLG Values
-----+-----+-----
100       3       10
```

show rsvp srlg-group parameters output details

Field	Description
Group-ID	A unique ID generated for a set of SRLG values. This ID is used in tunnel name to maintain SRLG uniqueness.
Refcnt	Number of auto bypass tunnels using the group ID in their name.
SRLG Values	A set of SRLG values for which a unique ID is generated.

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
CSPF	Constrained Shortest Path First. An extension of shortest path first (SPF). The path computed using CSPF is the shortest path that fulfills a set of constraints. After running the shortest path algorithm, the paths are pruned, removing those links that violate a given set of constraints.
LSP	Label Switched Path. A sequence of routers that cooperatively perform Multi-Protocol Label Switching (MPLS) operations for a packet stream. An LSP is a unidirectional, point-to-point, half-duplex connection carrying information downstream from the ingress (first) router to the egress (last) router. The ingress and egress routers cannot be the same device.
OSPF	Open Shortest Path First. An Interior Gateway Protocol (IGP) based on link-state routing. OSPF is widely deployed in large networks because of its efficient use of network bandwidth and its rapid convergence after changes in topology.
PLR	Point of Local Repair. It refers to a router's capability within a network to quickly reroute traffic around a failed link or node.
RSVP	Resource Reservation Protocol. A signalling protocol for reserving resources across a network. RSVP is rarely used by itself, but Resource Reservation Protocol—Traffic Engineering (RSVP-TE) is widely used.
SRLG	Shared Risk Link. Group. It refers to a group of links that share a common risk of failure due to factors such as physical proximity, geographic location, or shared resources.

CHAPTER 7 Auto-Bandwidth with RSVP-TE

Overview

Automatic bandwidth allows to dynamically adjust bandwidth reservation based on the measured traffic. RSVP automatic bandwidth monitors the traffic rate on a Label Switched Path (LSP) and resizes the bandwidth to align it closely with the traffic in the tunnel. RSVP automatic bandwidth is configured on individual LSPs at every headend router.

Auto bandwidth can be added to an operational LSP at any time, but no bandwidth change occurs until a future trigger event or auto bandwidth profile configured with initial bandwidth or minimum bandwidth. Auto bandwidth may also be removed from an operational LSP at any time and this would re-signal the LSP with no bandwidth reservation.

Feature Characteristics

The characteristics of the RSVP auto-bandwidth are:

- RSVP-TE auto bandwidth provides the means to automatically adjust the bandwidth allocation for traffic engineering tunnels based on their measured traffic load.
- This feature samples the average output rate for each tunnel marked for automatic bandwidth adjustment. For each marked tunnel, this feature periodically adjusts the tunnel's allocated bandwidth to the largest eligible sample for the tunnel since the last adjustment.
- The frequency with which tunnel bandwidth is adjusted and the allowable range of adjustments should be configurable on a per-auto-bandwidth profile basis.
- In addition, the sampling interval and the interval over which to average tunnel traffic to obtain the average output rate is user-configurable on a per-auto-bandwidth profile basis.

Note:

- Convergence on redundancy may require bidirectional traffic or MAC aging.
- The feature relies on stat_id allocation to tunnel entities, and there is a limit on the maximum number of stat_ids (which varies based on the chip variant). If a tunnel is not associated with a stat entity, traffic rate samples cannot be fetched for those tunnels.
- RSVP Graceful Restart is not supported for automatic bandwidth. When a GR is performed, RSVP will not store the current bandwidth for the reservation. It will use either the initial bandwidth (if configured), the minimum bandwidth, or the highest bandwidth of the on-boot sample (if auto-bandwidth-on-boot is configured).
- The auto bandwidth feature relies on the hardware's ability to collect tunnel traffic counters. In Qumran1 devices, the "hardware-profile statistics tunnel-lif enable" command must be enabled, and the system must be reloaded for the change to take effect. Without the tunnel statistics profile, auto bandwidth will not process traffic rates and will be ineffective. Note that, only 2 statistics profiles shall be configured as this is the hardware limitation.
- Auto bandwidth and manual bandwidth configurations are mutually exclusive. Auto bandwidth allows for configuring an initial bandwidth, which will be used as the session's initial bandwidth when auto bandwidth is associated with a trunk. If the initial bandwidth is not configured, the minimum bandwidth will be used to initialize the session bandwidth.
- For tunnels with only one hop, the no PHP (default config) must be set for the rate to be computed correctly.

Benefits

In large MPLS transport networks in service provider settings with this capability:

- The network can react faster to sudden bursts of traffic in near real-time and not rely on manual intervention.
- Effective use of bandwidth resources by minimizing the over-subscription/padding of LSP bandwidth.
- Maximizes the usage of available bandwidth and optimizes the network effectively to use preferred, shorter latency, paths first.

Prerequisites

Define Interfaces and Loopback Addresses

Configure Layer 3 interfaces, like port channel interfaces (e.g., po1), and assign specific IP addresses for proper identification and routing. Additionally, assign loopback IP addresses to establish essential points of connectivity. These configurations establish the efficient network routing and communication.

```
!
interface lo
  ip address 127.0.0.1/8
  ip address 100.1.1.1/32 secondary
  ipv6 address ::1/128
!
interface xel
  ip address 1.1.1.1/24
!
```

Configure IGP for Dynamic Routing

Configure IGP for dynamic routing by following the steps mentioned. This setup includes enabling ISIS for dynamic routing and configuring OSPF for the network.

ISIS Configuration

1. **Enable ISIS on all nodes:** Ensure that ISIS is running across the network to facilitate dynamic routing.
2. **Define ISIS Router Instances:** Set up instances to match loopback IP addresses.
3. **Add Network Segments to ISIS Areas:** This ensures proper route distribution.
4. **Set up Neighbor Relationships:** Use loopback IP addresses to establish these relationships for efficient route advertisement and convergence.

```
!
router isis 1
  is-type level-2-only
  metric-style wide
  mpls traffic-eng router-id 100.1.1.1
  mpls traffic-eng level-2
  capability cspf
  dynamic-hostname
  fast-reroute ti-lfa level-2 proto ipv4
  net 49.0000.0000.0001.00
  passive-interface lo
!
interface xel
  isis network point-to-point
```

```
ip router isis 1
!
```

OSPF Configuration

1. **Configure OSPF Router ID:** Assign a unique router ID for OSPF operations.
2. **Define OSPF Networks:** Include the loopback IP and other network segments in the OSPF area for route distribution.

```
!
router ospf 100
  ospf router-id 100.1.1.1
  network 100.1.1.1/32 area 0.0.0.0
  network 1.1.1.1/24 area 0.0.0.0
!
```

Configure RSVP for Efficient Network Operation

Enable Resource Reservation Protocol (RSVP) on all nodes to optimize traffic routing and quality of service. RSVP reserves network resources along specified paths to enhance network performance and reliability.

```
!  
router rsvp  
!  
interface xel  
  label-switching  
  enable-rsvp  
!
```

Configure the RSVP Primary Path and Trunk

Establish a trunk is required on edge routers participating in label-switching using defined path. Configuring the RSVP path is optional.

```
!  
rsvp-path PE1-PE2-1 mpls  
  1.1.1.2 strict  
  1.1.2.1 strict  
!  
rsvp-trunk PE1-PE2 ipv4  
  reoptimize  
  primary fast-reroute protection facility  
  primary fast-reroute node-protection  
  primary path PE1-PE2-1  
  from 100.1.1.1  
  to 100.1.1.3  
!
```

Configuration for RSVP Auto-Bandwidth

Configure various nodes within the topology to set up a RSVP-Auto bypass tunnels.

Topology

The sample topology includes Edge Nodes (PE1 and PE2) and core Nodes (P1).

Primary path is defined via PE1-P1-PE2.

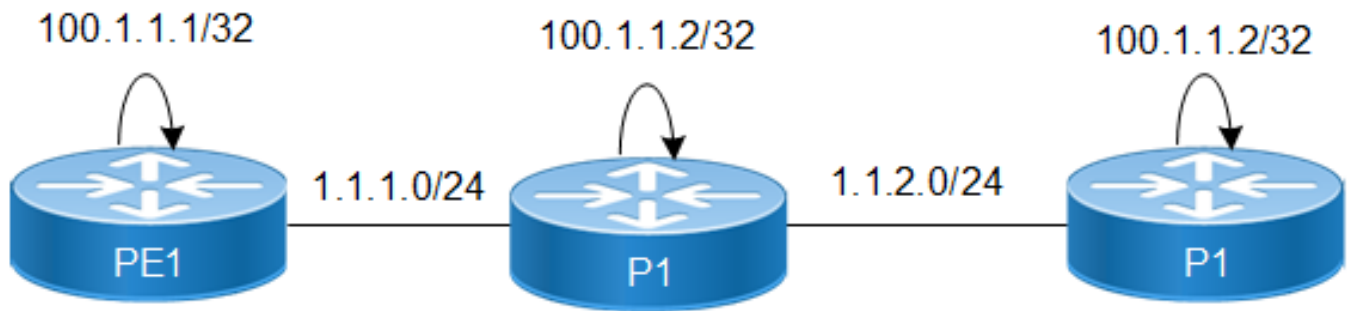


Figure 7-4: RSVP-Auto Bypass Tunnel Setup

Configure RSVP Auto Bandwidth on PE1 Router

1. Create auto-bandwidth Profile.

```
(config)# rsvp-auto-bandwidth AUTO-BW
(config-auto-bandwidth)# commit
```
2. Set the Sample interval & adjust interval.

```
(config-auto-bandwidth)# sample-interval 1
(config-auto-bandwidth)# adjust-interval 5
```
3. Set the minimum & maximum bandwidth rate.

```
(config-auto-bandwidth)# minimum-bandwidth 200m
(config-auto-bandwidth)# maximum-bandwidth 500m
```
4. Set the overflow-threshold & underflow-threshold.

```
(config-auto-bandwidth)# overflow-threshold absolute 100m
(config-auto-bandwidth)# underflow-threshold absolute 50m
```
5. Set the overflow & underflow limit.

```
(config-auto-bandwidth)# overflow-limit 2
(config-auto-bandwidth)# underflow-limit 2
```
6. Set the maximum number of consecutive times the average bandwidth can exceed the maximum threshold bandwidth before the exceed action is applied.

```
(config-auto-bandwidth)# maximum-bandwidth-exceed-limit 2
(config-auto-bandwidth)#maximum-bandwidth-exceed-action teardown
(config-auto-bandwidth)#commit
```

Running configuration on PE1 router is as follows:

```
#show running-config rsvp
!
router rsvp
!
!
interface xe1
  enable-rsvp
!
interface xe2
  enable-rsvp
!
```

```

!
!
!
rsvp-auto-bandwidth AUTO-BW
  sample-interval 1
  adjust-interval 5
  minimum-bandwidth 200m
  maximum-bandwidth 500m
  overflow-threshold absolute 100m
  underflow-threshold absolute 50m
  overflow-limit 2
  underflow-limit 2
  maximum-bandwidth-exceed-limit 2
  maximum-bandwidth-exceed-action teardown
!
rsvp-trunk PE1-PE2 ipv4
  reoptimize
  primary fast-reroute protection facility
  primary fast-reroute node-protection
  primary path PE1-PE2-1
  auto-bandwidth AUTO-BW
  from 100.1.1.1
  to 100.1.1.3
!

```

Validation

Verify auto bandwidth adjustments information as below:

Send the sample rate with 200MBPS and verify the auto bandwidth adjustments as below:

```

#show rsvp trunk auto-bandwidth detail
Session: PE1-PE2-Primary, Tunnel-id: 5002, LSP-ID: 2202, Egress: 100.1.1.3

```

```

-----
Sample Interval                : 1 minutes
Adjustment Interval            : 5 minutes
Minimum Samples required for processing : 1
Initialization Bandwidth       : 0
Minimum Bandwidth              : 200m
Maximum Bandwidth              : 500m
Overflow Threshold Bandwidth    : 100m
Underflow Threshold Bandwidth   : 50m
Overflow Threshold Activate Bandwidth : 0
Underflow Threshold Activate Bandwidth : 0
Overflow Limit                  : 2
Underflow Limit                 : 2
Max. Bandwidth Exceed Limit     : 2

```

```

-----
Max-BW-exceed-limit action     : teardown
Resignal-failure-action        : notify
Monitor Bandwidth              : No
-----

```

```

Minimum Average Bandwidth      : 0
Maximum Average Bandwidth      : 202.8m
Total Overflow Count           : 0
Consecutive Overflow Count     : 0
Consecutive Eligible Overflow Count : 0
Total Underflow Count          : 0
Consecutive Underflow Count    : 0
Consecutive Eligible Underflow Count : 0
Max. Bandwidth Exceed Count    : 0
Teardown Count                 : 0

```

```

-----
Last Bandwidth                  : 0
Last Requested Bandwidth       : 0
Last Signaled Bandwidth        : 0
Current Bandwidth               : 200m
Highest Bandwidth               : 203m

```

```

-----
Time for Next Sample request    : 48 seconds
Time for Next Adjustment        : 2 minutes, 57 seconds
Time of Last Bandwidth Request  : N/A
Time of Last Bandwidth Signal   : N/A
Time of Last Adjustment         : N/A
Time of Highest Bandwidth Marked : 2024 Jun 25 09:56:19

```

```

-----
Total Auto-Bandwidth Adjustments : 0
Successful Adjustments            : 0
Failed Adjustments                : 0

```

```

-----
Samples collected in the current adjustment cycle:
  [Sample 1-5]      : 202.8m   202.6m

```

```
#show rsvp trunk auto-bandwidth
```

```

-----+-----+-----+-----+-----+-----+-----+-----+-----
----+-----+-----+-----+-----+-----+-----+-----+-----
Trunk-Name      Trunk      LSP      Last      Requested  Signaled   Current   Highest
Adjust-Time    Last-Adjust
                ID         ID         BW         BW         BW         BW         BW
Left(sec)      Time
-----+-----+-----+-----+-----+-----+-----+-----+-----
----+-----+-----+-----+-----+-----+-----+-----+-----
PE1-PE2        5002        2202        0          0          0          200m      203m      176
NA

```

Overflow:

Current bandwidth is adjusted to 290.4MBPS. Then, send the sample rate which is more than overflow threshold i.e, 340.1MBPS , 377.2MBPS.

As per the below output current bandwidth is more than overflow threshold bandwidth and consecutively two samples are received and it is more than the overflow limit.

So current BW is adjusted to 377.2mbps after 2 consecutive samples collected as per the Maximum Average Bandwidth.

#show rsvp trunk auto-bandwidth detail

Session: PE1-PE2-Primary, Tunnel-id: 5002, LSP-ID: 2202, Egress: 100.1.1.3

Sample Interval	: 1 minutes
Adjustment Interval	: 5 minutes
Minimum Samples required for processing	: 1
Initialization Bandwidth	: 200m
Minimum Bandwidth	: 100m
Maximum Bandwidth	: 500m
Overflow Threshold Bandwidth	: 40m
Underflow Threshold Bandwidth	: 30m
Overflow Threshold Activate Bandwidth	: 0
Underflow Threshold Activate Bandwidth	: 0
Overflow Limit	: 2
Underflow Limit	: 2
Max. Bandwidth Exceed Limit	: 2

Max-BW-exceed-limit action	: teardown
Resignal-failure-action	: notify
Monitor Bandwidth	: No

Minimum Average Bandwidth	: 0
Maximum Average Bandwidth	: 340.1m
Total Overflow Count	: 1
Consecutive Overflow Count	: 1
Consecutive Eligible Overflow Count	: 1
Total Underflow Count	: 0
Consecutive Underflow Count	: 0
Consecutive Eligible Underflow Count	: 0
Max. Bandwidth Exceed Count	: 0
Teardown Count	: 0

Last Bandwidth	: 190.7m
Last Requested Bandwidth	: 290.4m
Last Signaled Bandwidth	: 290.4m
Current Bandwidth	: 290.4m
Highest Bandwidth	: 340.1m

Time for Next Sample request	: 0 seconds
Time for Next Adjustment	: 0 seconds
Time of Last Bandwidth Request	: 2024 Jun 25 10:28:32
Time of Last Bandwidth Signal	: 2024 Jun 25 10:28:32
Time of Last Adjustment	: 2024 Jun 25 10:28:32
Time of Highest Bandwidth Marked	: 2024 Jun 25 10:29:35

Total Auto-Bandwidth Adjustments	: 4
Successful Adjustments	: 4
Failed Adjustments	: 0

Samples collected in the current adjustment cycle:
[Sample 1-5] : 340.1m

#show rsvp trunk auto-bandwidth detail

Session: PE1-PE2_1-Primary, Tunnel-id: 5002, LSP-ID: 2203, Egress: 100.1.1.3

Sample Interval	: 1 minutes
Adjustment Interval	: 5 minutes
Minimum Samples required for processing	: 1
Initialization Bandwidth	: 200m
Minimum Bandwidth	: 100m
Maximum Bandwidth	: 500m
Overflow Threshold Bandwidth	: 40m
Underflow Threshold Bandwidth	: 30m
Overflow Threshold Activate Bandwidth	: 0
Underflow Threshold Activate Bandwidth	: 0
Overflow Limit	: 2
Underflow Limit	: 2
Max. Bandwidth Exceed Limit	: 2

Max-BW-exceed-limit action	: teardown
Resignal-failure-action	: notify
Monitor Bandwidth	: No

Minimum Average Bandwidth	: 0
Maximum Average Bandwidth	: 0
Total Overflow Count	: 0
Consecutive Overflow Count	: 0
Consecutive Eligible Overflow Count	: 0
Total Underflow Count	: 0
Consecutive Underflow Count	: 0
Consecutive Eligible Underflow Count	: 0
Max. Bandwidth Exceed Count	: 0
Teardown Count	: 0

Last Bandwidth	: 290.4m
Last Requested Bandwidth	: 377.2m
Last Signaled Bandwidth	: 377.2m
Current Bandwidth	: 377.2m
Highest Bandwidth	: 377.2m

Time for Next Sample request	: 59 seconds
Time for Next Adjustment	: 0 seconds
Time of Last Bandwidth Request	: 2024 Jun 25 10:30:42
Time of Last Bandwidth Signal	: 2024 Jun 25 10:30:42
Time of Last Adjustment	: 2024 Jun 25 10:30:42
Time of Highest Bandwidth Marked	: 2024 Jun 25 10:30:42

Total Auto-Bandwidth Adjustments	: 5
Successful Adjustments	: 5
Failed Adjustments	: 0

Samples collected in the current adjustment cycle:

=====

Underflow:

Scenario 1 :

Current bandwidth is adjusted to 377.2 mbps. Then, send the sample rate which is less than underflow threshold i.e, 317.3 mbps , 310 mbps.

As per the below output current bandwidth is more than underflow threshold bandwidth and consecutively two samples are received and it is more than the underflow limit.

So current BW is adjusted to 317.3 mbps after 2 consecutive samples collected as per the Minimum Average Bandwidth.

#show rsvp trunk auto-bandwidth detail

Session: PE1-PE2-Primary, Tunnel-id: 5002, LSP-ID: 2203, Egress: 100.1.1.3

Sample Interval	: 1 minutes
Adjustment Interval	: 5 minutes
Minimum Samples required for processing	: 1
Initialization Bandwidth	: 200m
Minimum Bandwidth	: 100m
Maximum Bandwidth	: 500m
Overflow Threshold Bandwidth	: 40m
Underflow Threshold Bandwidth	: 30m
Overflow Threshold Activate Bandwidth	: 0
Underflow Threshold Activate Bandwidth	: 0
Overflow Limit	: 2
Underflow Limit	: 2
Max. Bandwidth Exceed Limit	: 2

Max-BW-exceed-limit action	: teardown
Resignal-failure-action	: notify
Monitor Bandwidth	: No

Minimum Average Bandwidth	: 317.3m
Maximum Average Bandwidth	: 0
Total Overflow Count	: 0
Consecutive Overflow Count	: 0
Consecutive Eligible Overflow Count	: 0
Total Underflow Count	: 1
Consecutive Underflow Count	: 1
Consecutive Eligible Underflow Count	: 1
Max. Bandwidth Exceed Count	: 0
Teardown Count	: 0

Last Bandwidth	: 290.4m
----------------	----------

Last Requested Bandwidth	: 377.2m
Last Signaled Bandwidth	: 377.2m
Current Bandwidth	: 377.2m
Highest Bandwidth	: 377.2m

Time for Next Sample request	: 9 seconds
Time for Next Adjustment	: 3 minutes, 6 seconds
Time of Last Bandwidth Request	: 2024 Jun 25 10:30:42
Time of Last Bandwidth Signal	: 2024 Jun 25 10:30:42
Time of Last Adjustment	: 2024 Jun 25 10:30:42
Time of Highest Bandwidth Marked	: 2024 Jun 25 10:30:42

Total Auto-Bandwidth Adjustments	: 5
Successful Adjustments	: 5
Failed Adjustments	: 0

Samples collected in the current adjustment cycle:
[Sample 1-5] : 317.3m

#show rsvp trunk auto-bandwidth detail

Session: PE1-PE2-Primary, Tunnel-id: 5002, LSP-ID: 2204, Egress: 100.1.1.3

Sample Interval	: 1 minutes
Adjustment Interval	: 5 minutes
Minimum Samples required for processing	: 1
Initialization Bandwidth	: 200m
Minimum Bandwidth	: 100m
Maximum Bandwidth	: 500m
Overflow Threshold Bandwidth	: 40m
Underflow Threshold Bandwidth	: 30m
Overflow Threshold Activate Bandwidth	: 0
Underflow Threshold Activate Bandwidth	: 0
Overflow Limit	: 2
Underflow Limit	: 2
Max. Bandwidth Exceed Limit	: 2

Max-BW-exceed-limit action	: teardown
Resignal-failure-action	: notify
Monitor Bandwidth	: No

Minimum Average Bandwidth	: 0
Maximum Average Bandwidth	: 0
Total Overflow Count	: 0
Consecutive Overflow Count	: 0
Consecutive Eligible Overflow Count	: 0
Total Underflow Count	: 0
Consecutive Underflow Count	: 0
Consecutive Eligible Underflow Count	: 0

```
Max. Bandwidth Exceed Count      : 0
Teardown Count                  : 0
```

```
Last Bandwidth                   : 377.2m
Last Requested Bandwidth         : 317.3m
Last Signaled Bandwidth          : 317.3m
Current Bandwidth                : 317.3m
Highest Bandwidth                : 377.2m
```

```
Time for Next Sample request     : 56 seconds
Time for Next Adjustment         : 2 minutes, 46 seconds
Time of Last Bandwidth Request   : 2024 Jun 25 10:32:55
Time of Last Bandwidth Signal    : 2024 Jun 25 10:32:55
Time of Last Adjustment          : 2024 Jun 25 10:32:55
Time of Highest Bandwidth Marked : 2024 Jun 25 10:30:42
```

```
Total Auto-Bandwidth Adjustments : 6
Successful Adjustments            : 6
Failed Adjustments                : 0
```

Samples collected in the current adjustment cycle:

Scenario 2 :

Configure the Auto bandwidth Profile without configuring any underflow-limit. When all the samples in adjustment cycle receive with the underflow rate, then only underflow bandwidth adjustment will happen.

Below Example shows underflow limit as a Zero and current bandwidth is set to 8.5g and all the samples are received less than underflow-limit. So, the Bandwidth adjustment happens only after adjustment cycle.

#show rsvp trunk auto-bandwidth PE1-PE2

Session: PE1-PE2-Primary, Tunnel-id: 5002, LSP-ID: 2202, Egress: 100.1.1.3

```
Sample Interval                  : 1 minutes
Adjustment Interval              : 5 minutes
Minimum Samples required for processing : 1
Initialization Bandwidth        : 4g
Minimum Bandwidth                : 1g
Maximum Bandwidth                : 9g
Overflow Threshold Bandwidth     : 10% (851.2m)
Underflow Threshold Bandwidth    : 10% (851.2m)
Overflow Threshold Activate Bandwidth : 0
Underflow Threshold Activate Bandwidth : 0
Overflow Limit                   : 1
Underflow Limit                  : 0
Max. Bandwidth Exceed Limit     : 1
```

```
Max-BW-exceed-limit action      : notify
Resignal-failure-action         : notify
Monitor Bandwidth               : No
```

```
Minimum Average Bandwidth       : 6.5g
Maximum Average Bandwidth       : 0
```

```

Total Overflow Count           : 0
Consecutive Overflow Count     : 0
Consecutive Eligible Overflow Count : 0
Total Underflow Count         : 5
Consecutive Underflow Count    : 5
Consecutive Eligible Underflow Count : 5
Max. Bandwidth Exceed Count    : 0
Teardown Count                : 0

```

```

-----
Last Bandwidth                 : 6.2g
Last Requested Bandwidth       : 8.5g
Last Signaled Bandwidth        : 8.5g
Current Bandwidth              : 8.5g
Highest Bandwidth              : 8.6g

```

```

-----
Time for Next Sample request   : 17 seconds
Time for Next Adjustment       : 0 seconds
Time of Last Bandwidth Request : 2024 Jun 25 11:30:42
Time of Last Bandwidth Signal  : 2024 Jun 25 11:30:42
Time of Last Adjustment        : 2024 Jun 25 11:30:42
Time of Highest Bandwidth Marked : 2024 Jun 25 11:24:35

```

```

-----
Total Auto-Bandwidth Adjustments : 11
Successful Adjustments           : 11
Failed Adjustments               : 0

```

```

-----
Samples collected in the current adjustment cycle:
  [Sample 1-5]      : 6.5g      6.3g      6.4g      6.4g      6.4g

```

```
#show rsvp trunk auto-bandwidth
```

```

-----+-----+-----+-----+-----+-----+-----+-----+-----
+-----+-----+-----+-----+-----+-----+-----+-----+
Trunk-Name      Trunk   LSP      Last      Requested  Signaled   Current   Highest
Adjust-Time    Last-Adjust
                ID      ID      BW      BW      BW      BW      BW
Left(sec)      Time
-----+-----+-----+-----+-----+-----+-----+-----+
+-----+-----+-----+-----+-----+-----+-----+-----+
PE1-PE2        5002    2202    8.5g     6.5g     6.5g     6.5g     8.6g
277            2024 Jun 25 11:30:42

```

Configure RSVP Auto Bandwidth on Boot on PE1 Router

1. Create auto-bandwidth Profile.

```
(config)#router rsvp
```

2. Configure Auto bandwidth on boot and set the values for sample interval, Adjust interval and Adjust interval count.

```

(config-router)#auto-bandwidth-on-boot 1 5 1
(config-router)#commit

```

Validation

Verify auto bandwidth on boot adjustments information as below:

```
#show running-config rsvp
!
router rsvp
  auto-bandwidth-on-boot 1 5 1
!
!
!
!
!
!
#
#show rsvp trunk auto-bandwidth
```

*** On boot auto bandwidth is in progress for 2 minutes, 3 seconds ***

Trunk-Name	Trunk	LSP	Last	Requested	Signaled	Current	Highest
Adjust-Time	Last-Adjust	ID	BW	BW	BW	BW	BW
Left(sec)	Time	ID	BW	BW	BW	BW	BW
PE-1_to_PE-2_1	5002	2202	0	0	0	200m	144.6m
NA	NA						

Commands for RSVP Auto-Bandwidth

The RSVP auto-bandwidth uses the following configuration commands.

rsvp-auto-bandwidth

Use this command to configure an auto bandwidth profile. The profile will have default settings if any parameter not configured explicitly. User can configure parameters to their need within auto bandwidth profile.

Use `no` parameter of this command to delete auto bandwidth profile.

Command Syntax

```
rsvp-auto-bandwidth PROFILENAME
no rsvp-auto-bandwidth PROFILENAME
```

Parameters

<p><PROFILE_NAME ></p>	<p>Specifies the name assigned to the auto-bandwidth profile during configuration. The profile name can be a maximum of 64 characters in length.</p>
----------------------------------	--

Default

None

Command Mode

Config mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure an auto-bandwidth profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#commit
(config-auto-bandwidth)#exit
(config)#
```

The following example describes how to delete the auto bandwidth profile:

```
#configure terminal
(config)#no rsvp-auto-bandwidth bwp
(config)#commit
```

sample-interval

Use this command to configure a sample interval value in minutes on the auto bandwidth profile. Sample interval determines the frequency at which rate samples collected from associated trunks. Sample interval must not be configured more than adjust interval as no samples can be collected within an adjustment cycle in such case.

Note: Sample interval timers run per auto bandwidth profile and not per associated trunks. So, in case of bandwidth adjustments on trunks before adjustment cycle completion will leave the newly formed session with less number of samples in the remaining part of adjustment cycle. In order to avoid very few samples being processed, minimum-samples command shall be configured in absolute or percentage format.

Use the `no` parameter to remove the sample interval configuration.

Command Syntax

```
sample-interval <1 - 10080>
no sample-interval
```

Parameters

<1-10080>	Specifies the sample interval value in minutes.
-----------	---

Default

5 minutes

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure sample interval in the auto bandwidth profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#sample-interval 2
(config-auto-bandwidth)#commit
```

The following example describes how to remove configured sample interval in the auto bandwidth profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no sample-interval
(config-auto-bandwidth)#commit
```

adjust-interval

Use this command to configure a adjust interval value in minutes on the auto bandwidth profile. Adjust interval determines the duration of the adjustment cycle. Bandwidth update decisions for active session of associated trunks are taken after every adjustment cycle. Adjust interval must not be configured less than sample interval as no samples can be collected within an adjustment cycle in such case.

Note: Adjust interval timers run per auto bandwidth profile and not per associated trunks. So, in case of bandwidth adjustments on trunks before adjustment cycle completion will leave the newly formed session with less number of samples in the remaining part of adjustment cycle. In order to avoid very few samples being processed, minimum-samples command shall be configured in absolute or percentage format.

Use the `no` parameter to remove the adjust interval configuration.

Command Syntax

```
adjust-interval <5 - 10080>
no adjust-interval
```

Parameters

<5-10080>	Specifies the adjust interval value in minutes.
-----------	---

Default

30 minutes

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure adjust interval in the auto bandwidth profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#adjust-interval 60
(config-auto-bandwidth)#commit
```

The following example describes how to remove configured adjust interval in the auto bandwidth profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no adjust-interval
(config-auto-bandwidth)#commit
```

minimum-bandwidth

Use this command to configure minimum bandwidth on the auto bandwidth profile. Even when traffic flow is much lesser than minimum bandwidth, LSP will be reserved with the configured minimum bandwidth during bandwidth adjustment process. When auto bandwidth profile associated with trunk, LSP will be signaled with minimum bandwidth when initial bandwidth is not configured in the profile.

Use the `no` parameter to remove the minimum bandwidth configuration from the profile.

Command Syntax

```
minimum-bandwidth BANDWIDTH
no minimum-bandwidth
```

Parameters

BANDWIDTH	Specifies the bandwidth value in the range of 1k to 999g.
-----------	---

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure minimum bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#minimum-bandwidth 100m
(config-auto-bandwidth)#commit
```

The following example describes how to remove the minimum bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no minimum-bandwidth
(config-auto-bandwidth)#commit
```

maximum-bandwidth

Use this command to configure maximum bandwidth on the auto bandwidth profile. Even when traffic flow is much higher than maximum bandwidth, LSP will be reserved with the configured maximum bandwidth during bandwidth adjustment process. Operator notification is generated if the traffic rate samples collected are higher than the maximum bandwidth but the reservation is limited to maximum bandwidth.

Note: When maximum bandwidth is configured, even a single traffic rate sample crossing the maximum bandwidth will trigger an MBB with maximum bandwidth reserved. If user doesn't wish to trigger an MBB for single sample of maximum bandwidth exceed, maximum-bandwidth-exceed-limit shall be configured with a value to mention the number of consecutive samples to cross maximum bandwidth to take further action.

Use the `no` parameter to remove the maximum bandwidth configuration from the profile.

Command Syntax

```
maximum-bandwidth BANDWIDTH
no maximum-bandwidth
```

Parameters

BANDWIDTH	Specifies the bandwidth value in the range of 1k to 999g.
-----------	---

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure maximum bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#maximum-bandwidth 900m
(config-auto-bandwidth)#commit
```

The following example describes how to remove the maximum bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no maximum-bandwidth
(config-auto-bandwidth)#commit
```

initial-bandwidth

Use this command to configure initial bandwidth on the auto bandwidth profile. When auto bandwidth profile associated with trunk, LSP will be signalled with initial bandwidth when initial bandwidth is configured in the profile. For trunks which are already associated with auto bandwidth profile and the system going through reload, initial bandwidth will not be applicable as on boot computation will trigger to update active sessions with bandwidth as per the on boot period traffic rate sample computation.

Use the `no` parameter to remove the initial bandwidth configuration from the profile.

Command Syntax

```
initial-bandwidth BANDWIDTH
no initial-bandwidth
```

Parameters

BANDWIDTH	Specifies the bandwidth value in the range of 1k to 999g.
-----------	---

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure initial bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#initial-bandwidth 500m
(config-auto-bandwidth)#commit
```

The following example describes how to remove the initial bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no initial-bandwidth
(config-auto-bandwidth)#commit
```

underflow-threshold

Use this command to configure underflow threshold in percentage or absolute value format on the auto bandwidth profile. Underflow threshold sets the amount of reduction in traffic rate sample to detect an eligible underflow. As an example, absolute underflow threshold 10m when current bandwidth is 200m means, a traffic rate sample of 190.1m will not be considered eligible underflow sample and a sample of 189.9m will be considered eligible underflow sample.

When all the traffic rate samples collected for an auto bandwidth profile associated trunk cross underflow threshold in an adjustment cycle, then the highest eligible traffic rate sample will be considered to re-signal the session with new bandwidth at the end of an adjustment cycle.

Constraints like underflow-limit and underflow-threshold-activate-bandwidth will add additional logic on how bandwidth update action is taken. This will be discussed in respective sections.

If underflow threshold is not configured, then minor reduction in traffic rate sample also will be considered as eligible underflow bandwidth sample. So, underflow and overflow threshold is a recommended configuration even though it is not mandatory.

When underflow threshold is configured in percentage, the threshold will be computed based on the current bandwidth and the percentage value. Example, underflow threshold 10% for a current bandwidth of 100m means a sample of 90m

or lesser will be considered eligible underflow sample. Underflow threshold can be configured either as absolute value or in percentage but not both.

Use the `no` parameter to remove the underflow bandwidth configuration from the profile.

Command Syntax

```
underflow-threshold (percent <1-100>) | (absolute BANDWIDTH)
no underflow-threshold (percent | absolute)
```

Parameters

<1-100>	Specifies the underflow threshold value in percentage.
BANDWIDTH	Specifies the bandwidth value in the range of 1k to 999g.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure underflow bandwidth in percentage format in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#underflow-threshold percent 10
(config-auto-bandwidth)#commit
```

The following example describes how to remove the underflow bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no underflow-threshold percent
(config-auto-bandwidth)#commit
```

overflow-threshold

Use this command to configure overflow threshold in percentage or absolute value format on the auto bandwidth profile. Overflow threshold sets the amount of increase in traffic rate sample required to detect an eligible overflow. As an example, absolute overflow threshold 10m when current bandwidth is 200m means, a traffic rate sample of 209.9m will not be considered eligible overflow sample and a sample of 210.1m will be considered eligible overflow sample.

When a traffic rate sample collected for an auto bandwidth profile associated trunk crosses overflow threshold in an adjustment cycle, then the highest eligible traffic rate sample will be considered to re-signal the session with new bandwidth at the end of adjustment cycle.

Constraints like overflow-limit and overflow-threshold-activate-bandwidth will add additional logic on how bandwidth update action is taken. This will be discussed in respective sections.

If overflow threshold is not configured, then minor increase in traffic rate sample also will be considered as eligible overflow bandwidth sample. So, underflow and overflow threshold is a recommended configuration even though it is not mandatory.

When overflow threshold is configured in percentage, the threshold will be computed based on the current bandwidth and the percentage value. Example, overflow threshold 10% for a current bandwidth of 100m means a sample of 110m or more will be considered eligible overflow sample. Overflow threshold can be configured either as absolute value or in percentage but not both.

Use the `no` parameter to remove the underflow bandwidth configuration from the profile.

Command Syntax

```
overflow-threshold (percent <1-100>) | (absolute BANDWIDTH)
no overflow-threshold (percent | absolute)
```

Parameters

<1-100>	Specifies the overflow threshold value in percentage.
BANDWIDTH	Specifies the bandwidth value in the range of 1k to 999g.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure underflow bandwidth in absolute format in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#overflow-threshold absolute 10m
(config-auto-bandwidth)#commit
```

The following example describes how to remove the underflow bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no overflow-threshold absolute
(config-auto-bandwidth)#commit
```

underflow-threshold-activate-bandwidth

Use this command to configure absolute bandwidth range to allow bandwidth re-signalling when underflow threshold and underflow limit criteria matched. This configuration helps to limit the underflow bandwidth reservation update for certain range of bandwidth.

As an example, if the current bandwidth is 500m and the underflow threshold is 10%. So, normally, if all traffic rate samples collected are in the range of 400m to 450m, session will be re-signalled to reserve new bandwidth. However, if underflow-threshold-activate-bandwidth is configured as 300m, then the traffic rate samples in the range of 400m to

450m will not trigger bandwidth update. Only when the traffic rate samples are less than 300m, then it will be considered as eligible sample.

The configuration creates an absolute bandwidth range for underflow samples to be eligible. The bandwidth range for underflow eligibility will be minimum bandwidth (or zero when minimum bandwidth is not configured) to underflow-threshold-activate-bandwidth value. When this command is not configured, there won't be any such absolute range and only underflow-threshold and underflow-limit will be considered for computation, if configured.

Use the `no` parameter to remove the underflow threshold activate bandwidth configuration from the profile.

Command Syntax

```
underflow-threshold-activate-bandwidth BANDWIDTH
no underflow-threshold-activate-bandwidth
```

Parameters

BANDWIDTH	Specifies the bandwidth value in the range of 1k to 999g.
-----------	---

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure underflow threshold activate bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#underflow-threshold-activate-bandwidth 500m
(config-auto-bandwidth)#commit
```

The following example describes how to remove the underflow threshold activate bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no underflow-threshold-activate-bandwidth
(config-auto-bandwidth)#commit
```

overflow-threshold-activate-bandwidth

Use this command to configure absolute bandwidth range to allow bandwidth re-signalling when overflow threshold and overflow limit criteria matched. This configuration helps to limit the overflow bandwidth reservation update for certain range of bandwidth.

As an example, if the current bandwidth is 100m and the overflow threshold is 10%. Normally, if a traffic rate sample collected is in the range of 110m to 150m, session will be re-signalled to reserve new bandwidth. However, if overflow-threshold-activate-bandwidth is configured as 300m, then the traffic rate samples in the range of 110m to 150m will not trigger bandwidth update. Only when the traffic rate samples are more than 300m, then it will be considered as eligible sample.

The configuration creates an absolute bandwidth range for overflow samples to be eligible. The bandwidth range for overflow eligibility will be overflow-threshold-activate-bandwidth value to a practical infinity. When this command is not configured, there won't be any such absolute range and only overflow-threshold and overflow-limit will be considered for computation, if configured.

Use the `no` parameter to remove the overflow threshold activate bandwidth configuration from the profile.

Command Syntax

```
overflow-threshold-activate-bandwidth BANDWIDTH
no overflow-threshold-activate-bandwidth
```

Parameters

BANDWIDTH	Specifies the bandwidth value in the range of 1k to 999g.
-----------	---

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure overflow threshold activate bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#overflow-threshold-activate-bandwidth 500m
(config-auto-bandwidth)#commit
```

The following example describes how to remove the overflow threshold activate bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no overflow-threshold-activate-bandwidth
(config-auto-bandwidth)#commit
```

underflow-limit

Use this command to configure underflow limit on the auto bandwidth profile. When underflow limit is configured, if the traffic rate samples collected on the associated session consecutively crosses underflow threshold for underflow limit times, then the bandwidth adjustment will be triggered immediately without waiting for adjustment cycle completion. When underflow-threshold-activate-bandwidth is configured, even this criteria is considered to mark a sample as eligible underflow sample.

Only when underflow limit is configured, underflow adjustment may happen before the completion of adjustment cycle. Otherwise, underflow adjustment considered only at the completion of adjustment cycle when all samples found to be eligible underflow sample.

Use the `no` parameter to remove the underflow limit configuration from the profile.

Command Syntax

```
underflow-limit <1-10080>
no underflow-limit
```

Parameters

<1-10080> Specifies the underflow limit value for consecutive eligible samples.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure underflow limit in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#underflow-limit 3
(config-auto-bandwidth)#commit
```

The following example describes how to remove the underflow limit configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no underflow-limit
(config-auto-bandwidth)#commit
```

overflow-limit

Use this command to configure overflow limit on the auto bandwidth profile. When overflow limit is configured, if the traffic rate samples collected on the associated session consecutively crosses overflow threshold for overflow limit times, then the bandwidth adjustment will be triggered immediately without waiting for adjustment cycle completion. When overflow-threshold-activate-bandwidth is configured, even this criteria is considered to mark a sample as eligible underflow sample.

Only when overflow limit is configured, overflow adjustment may happen before the completion of adjustment cycle. Otherwise, overflow adjustment considered only at the completion of adjustment cycle when a sample found to be eligible overflow sample.

If the traffic rate sample crosses maximum bandwidth, then maximum-bandwidth-exceed-limit configuration comes into picture and by default, a single sample crossing maximum bandwidth triggers bandwidth update. This situation is different from overflow scenario.

Use the `no` parameter to remove the overflow limit configuration from the profile.

Command Syntax

```
overflow-limit <1-10080>
no overflow-limit
```

Parameters

<1-10080> Specifies the overflow limit value for consecutive eligible samples.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure overflow limit in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#overflow-limit 3
(config-auto-bandwidth)#commit
```

The following example describes how to remove the overflow limit configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no overflow-limit
(config-auto-bandwidth)#commit
```

maximum-bandwidth-exceed-limit

Use this command to configure maximum bandwidth exceed limit on the auto bandwidth profile. When maximum bandwidth exceed limit is configured, if the traffic rate samples collected on the associated session consecutively crosses maximum bandwidth for maximum-bandwidth-exceed-limit times, then the action will be triggered immediately without waiting for adjustment cycle completion. When maximum-bandwidth-exceed-limit is not configured, a single sample exceeding maximum bandwidth will trigger an action which is re-signal with updated bandwidth or restart the session with initial or minimum bandwidth based on the action configured.

When maximum bandwidth is not configured, maximum bandwidth exceed limit configuration doesn't have any significance. Overflow limit and maximum bandwidth exceed limits are independent commands with different significance with latter associated with maximum bandwidth.

Use the `no` parameter to remove the maximum bandwidth exceed limit configuration from the profile.

Command Syntax

```
maximum-bandwidth-exceed-limit <1-10080>
no maximum-bandwidth-exceed-limit
```

Parameters

<1-10080> Specifies the maximum bandwidth exceed limit value for consecutive eligible samples.

Default

1

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure maximum bandwidth exceed limit in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#maximum-bandwidth-exceed-limit 2
(config-auto-bandwidth)#commit
```

The following example describes how to remove the maximum bandwidth exceed limit configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no maximum-bandwidth-exceed-limit
(config-auto-bandwidth)#commit
```

maximum-bandwidth-exceed-action

Use this command to configure maximum bandwidth exceed action on the auto bandwidth profile. When the traffic rate samples collected on the associated session consecutively crosses maximum bandwidth for maximum-bandwidth-exceed-limit times (or one time if limit is not configured), then the action to be triggered will be decided by this configuration. If not configured, default action is to re-signal the session with maximum bandwidth or ignore if session is already signalled with maximum bandwidth. In any case, user will be notified about the maximum bandwidth being exceeded. However, with exceed action configured as teardown, session will be released and restarted with initial bandwidth or minimum bandwidth if initial bandwidth is not configured.

This action will lead to service interruption if there are no alternate transport. So, this configuration is recommended to be used with full awareness of the impact.

Use the `no` parameter to remove the maximum bandwidth exceed action configuration from the profile.

Command Syntax

```
maximum-bandwidth-exceed-action (teardown)
no maximum-bandwidth-exceed-action
```

Parameters

teardown	Teardown the session exceeding maximum bandwidth.
----------	---

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure maximum bandwidth exceed action in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#maximum-bandwidth-exceed-action teardown
(config-auto-bandwidth)#commit
```

The following example describes how to remove the maximum bandwidth exceed action configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no maximum-bandwidth-exceed-action
(config-auto-bandwidth)#commit
```

resignal-failure-action

Use this command to configure an action on the auto bandwidth profile when the bandwidth update re-signalling fails on the associated session. By default, if re-signalling fails (3 attempts) for the updated bandwidth, it will be noted down as re-signalling failure and session will continue with its current bandwidth reservation. If severe actions to be taken on such re-signal failure, then teardown action can be configured which will release the current session and restart freshly with initial bandwidth or minimum bandwidth when initial bandwidth is not configured.

This action will lead to service interruption if there are no alternate transport. So, this configuration is recommended to be used with full awareness of the impact.

Use the `no` parameter to remove the re-signal failure action configuration from the profile.

Command Syntax

```
resignal-failure-action (teardown)
no resignal-failure-action
```

Parameters

<code>teardown</code>	Specifies the teardown the session when re-signalling with new bandwidth fails.
-----------------------	---

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure re-signal failure action in a profile:

```
#configure terminal
```



```
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#resignal-failure-action teardown
(config-auto-bandwidth)#commit
```

The following example describes how to remove the re-signal failure action configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no resignal-failure-action
(config-auto-bandwidth)#commit
```

sync-bandwidth

Use this command to configure bandwidth synchronization for primary and secondary sessions of an auto bandwidth profile associated trunk. With this configuration, in case the associated trunk is configured with primary and secondary sessions, every time primary session goes through a bandwidth update, secondary session also will be re-signalled with primary session's bandwidth. Thus, secondary path is determined with proper reservation constraints to ensure it is in the correct bandwidth reserved state when traffic switches to secondary.

Use the `no` parameter to remove synchronise bandwidth configuration from the profile.

Command Syntax

```
sync-bandwidth
no sync-bandwidth
```

Parameters

None

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure synchronize bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#sync-bandwidth
(config-auto-bandwidth)#commit
```

The following example describes how to remove the synchronise bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no sync-bandwidth
(config-auto-bandwidth)#commit
```

monitor-bandwidth

Use this command to configure only monitor the traffic rate samples and computation without taking any action. This command can be used to monitor the traffic behaviour without updating the active sessions. With this configuration, in case of overflow, underflow, adjustment cycle completion time computation results, maximum bandwidth exceed, etc., notification is provided without taking any action.

Use the `no` parameter to remove monitor bandwidth configuration from the profile.

Command Syntax

```
monitor-bandwidth
no monitor-bandwidth
```

Parameters

None

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure monitor bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#monitor-bandwidth
(config-auto-bandwidth)#commit
```

The following example describes how to remove the monitor bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no monitor-bandwidth
(config-auto-bandwidth)#commit
```

minimum-samples

Use this command to configure the minimum samples required in an adjustment cycle for bandwidth processing. Sample timers and Adjust timers are executed per auto bandwidth profile and not per associated trunk. Thus, there are scenarios of a trunk going through a bandwidth update few minutes ago and again ends up with adjustment cycle completion processing with very few samples collected. In order to avoid such scenarios, minimum samples required in an adjustment cycle to process the bandwidth shall be configured.

Configuration is accepted in both absolute and in percentage format. This gives user the flexibility to choose the format that suites their need. If sample interval and adjust interval expected to be fixed, then absolute configuration helps providing the requirement of exact number of minimum samples required to process. If exact number isn't important and there are chances of changing adjust interval or sample interval in future, then percentage format can be chosen. However, only one of the formats can be configured.

By default, even if there is one traffic rate sample during adjustment cycle completion, bandwidth will be processed. So, it will be recommended to have this configuration if users are keen on minimum of certain samples to be considered for bandwidth computation.

Use the `no` parameter to remove the minimum sample configuration from the profile.

Command Syntax

```
minimum-samples (percent <1-100>) | (absolute <1-10080>)  
no underflow-limit (percent | absolute)
```

Parameters

<1-10080>	Specifies the absolute value for minimum samples required in an adjustment cycle.
<1-100>	Specifies the minimum sample percentage required in an adjustment cycle.

Default

1 sample

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.2.

Example

The following example describes how to configure minimum samples in percentage format in a profile:

```
#configure terminal  
(config)#rsvp-auto-bandwidth bwp  
(config-auto-bandwidth)#minimum-samples percent 70  
(config-auto-bandwidth)#commit
```

The following example describes how to remove the minimum samples configuration from the profile:

```
#configure terminal  
(config)#rsvp-auto-bandwidth bwp  
(config-auto-bandwidth)#no minimum-samples percent  
(config-auto-bandwidth)#commit
```

auto-bandwidth

Use this command to attach an auto bandwidth profile to a trunk. When the auto bandwidth profile is attached to the trunk, active session will be re-signalled with initial bandwidth configured in the auto bandwidth profile or minimum bandwidth configured if initial bandwidth is not configured. Bandwidth update will be triggered only if there is variation in the bandwidth to be initialized. Attaching or detaching an auto bandwidth profile doesn't trigger any session flap and doesn't cause traffic impact.

When an auto bandwidth profile is associated with first trunk, sample interval and adjust interval timers will start and are stopped when the profile is removed from the last trunk.

Manual bandwidth configuration for the sessions and auto bandwidth profile attach are mutually exclusive and the configuring both of them on a trunk is not allowed.

Use the `no` parameter to remove the auto bandwidth profile from the trunk.

Command Syntax

```
auto-bandwidth PROFILENAME
no auto-bandwidth PROFILENAME
```

Parameters

PROFILENAME	Specifies the name of the auto bandwidth profile.
-------------	---

Default

None

Command Mode

Trunk mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to associate an auto bandwidth profile to a trunk:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#exit
(config)#rsvp-trunk t1
(config-trunk)#auto-bandwidth bwp
(config-trunk)#commit
```

The following example describes how to remove the auto bandwidth profile from the trunk:

```
#configure terminal
(config)#rsvp-trunk t1
(config-trunk)#no auto-bandwidth bwp
(config-trunk)#commit
```

auto-bandwidth-on-boot

Use this command to configure on boot sample interval, adjust interval and number of adjustment cycles. When the system is reloaded and comes up, all active sessions of trunks associated with auto bandwidth profiles run a relatively faster adjustment cycle with quicker sample collection to settle the sessions with accurate bandwidth reservation.

By default, sample interval is 1 minute, adjust interval is 5 minutes and the adjustment cycle runs one time. After the adjustment cycle completion, samples of each associated trunks computed to re-signal the sessions with updated bandwidth. Then the auto bandwidth profile based adjustment cycle starts. If user wishes to run the boot up time rigorous sample computation for longer duration or multiple rounds, then it shall be configured. The configurations will apply from system reload if the configuration is saved. Properties of auto bandwidth profiles will not be applied during boot up time computation.

Use the `no` parameter to remove the auto bandwidth profile from the trunk.

Command Syntax

```
auto-bandwidth-on-boot <1-10080> <1-10080> <1-10>
no auto-bandwidth-on-boot
```

Parameters

<1-10080>	On boot sample interval value in minutes.
<1-10080>	On boot adjustment interval value in minutes.
<1-10>	Specifies the number of adjustment cycles to run on boot.

Default

Sample interval 1 minute, adjust interval 5 minutes and 1 adjustment cycle.

Command Mode

Router mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure on boot auto bandwidth parameters:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bandwidth-on-boot 1 10 3
(config-router)#commit
```

The following example describes how to reset on boot auto bandwidth parameters:

```
#configure terminal
(config)#router rsvp
(config-router)#no auto-bandwidth-on-boot
(config-router)#commit
```

force-auto-bandwidth-adjustment

Use this command to force a bandwidth adjustment on a trunk associated with auto bandwidth profile. When the command is executed without bandwidth value mentioned, traffic rate samples collected till the time are used to compute the bandwidth to be adjusted. In case of bandwidth value mentioned in the command, the bandwidth is verified for eligibility and bandwidth update will be triggered.

Command Syntax

```
rsvp-trunk TRUNKNAME force-auto-bandwidth-adjustment (BANDWIDTH|)
```

Parameters

TRUNKNAME	Specifies the name of the trunk to go through forced bandwidth adjustment.
BANDWIDTH	Specifies the bandwidth value in the range of 1k to 999g.

Default

None

Command Mode

Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how you can force a bandwidth adjustment for a trunk with an auto bandwidth profile:

```
#rsvp-trunk t1 force-auto-bandwidth-adjustment
```

clear rsvp auto-bandwidth

Use this command to reset the auto bandwidth adjustment cycle by clearing all the traffic samples collected by the associated trunks and by restarting sample and adjust timers. If auto bandwidth profile name is not mentioned, then all trunks associated with any auto bandwidth profile will be reset and computation will start freshly.

Command Syntax

```
clear rsvp auto-bandwidth (PROFILENAME|)
```

Parameters

PROFILENAME	Specifies the name of the auto bandwidth profile.
-------------	---

Default

None

Command Mode

Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to restart processing of an auto bandwidth profile:

```
#clear rsvp auto-bandwidth bwp
```

clear rsvp trunk auto-bandwidth-statistics

Use this command to clear the statistics maintained on a trunk associated with auto bandwidth profile. Statistics will be mainly the highest watermarked bandwidth, last adjusted bandwidth, how many times adjustment triggered, status of the adjustment trigger, etc. This command will only clear the auto bandwidth statistics for the trunk and doesn't impact the operation of auto bandwidth including the traffic rate samples collected for the current adjustment cycle.

Command Syntax

```
clear rsvp trunk TRUNKNAME auto-bandwidth-statistics
```

Parameters

TRUNKNAME	Specifies the name of the trunk associated with auto bandwidth profile.
-----------	---

Default

None

Command Mode

Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to clear the auto bandwidth statistics on a trunk which is associated with the auto bandwidth profile:

```
#clear rsvp trunk t1 auto-bandwidth-statistics
```

Show Commands for RSVP

show rsvp auto-bandwidth

Use this command to display auto bandwidth profile specific information.

Command Syntax

```
show rsvp auto-bandwidth
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for viewing all the auto bandwidth profiles:

```
#show rsvp auto-bandwidth
```

```
Profile Name : bwp
```

```
-----  
Sample Interval           : 5 minutes (due in 4 minutes)  
Adjust Interval          : 30 minutes (due in 29 minutes)  
Minimum Samples required for processing : 1  
Initial Bandwidth         : 0  
Minimum bandwidth        : 0  
Maximum bandwidth        : 100m  
Underflow Threshold Bandwidth : 5m
```

```

Overflow Threshold Bandwidth      : 5m
Underflow Threshold Activate Bandwidth : 0
Overflow Threshold Activate Bandwidth : 0
Overflow Limit                    : 3
Underflow Limit                   : 3
Maximum Bandwidth Exceed Limit    : 1
Maximum Bandwidth Exceed Action   : notify
Re-signal Failure Action          : notify
Sync Bandwidth                    : No
Monitor Bandwidth                 : No
No. of trunks associated           : 1

```

show rsvp auto-bandwidth detail

Use this command to display a specific auto bandwidth profile information or all auto bandwidth profile information along with associated trunk details.

Command Syntax

```
show rsvp auto-bandwidth (PROFILENAME | detail)
```

Parameters

PROFILENAME	Specifies the name of the auto bandwidth profile.
detail	Specifies detailed information of all the auto bandwidth profiles.

Command Mode

Exec mode and Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example is for viewing all the auto bandwidth profiles along with associated trunks:

```
#show rsvp auto-bandwidth detail
```

```

Profile Name : bwp
-----
Sample Interval      : 5 minutes (due in 4 minutes)
Adjust Interval      : 30 minutes (due in 29 minutes)
Minimum Samples required for processing : 1
Initial Bandwidth    : 0
Minimum bandwidth    : 0
Maximum bandwidth    : 100m
Underflow Threshold Bandwidth : 5m
Overflow Threshold Bandwidth  : 5m
Underflow Threshold Activate Bandwidth : 0
Overflow Threshold Activate Bandwidth : 0
Overflow Limit        : 3
Underflow Limit       : 3
Maximum Bandwidth Exceed Limit : 1
Maximum Bandwidth Exceed Action : notify
Re-signal Failure Action : notify
Sync Bandwidth        : No
Monitor Bandwidth     : No

```


No. of trunks associated: 1

Trunk-Name	Trunk ID	LSP ID	Last BW	Requested BW	Signaled BW	Current BW	Highest Time	LastAdjust
t1	5001	2201	10.1m	22.5m	22.5m	22.5m	35.5m	2024 Jul 23

show rsvp trunk auto-bandwidth

Use this command to display the information of all the trunks associated with the auto bandwidth profile. This show command will display high level information like what is the last bandwidth, current bandwidth, last adjustment time, time left in adjustment cycle in seconds, etc.

Command Syntax

```
show rsvp trunk auto-bandwidth
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for viewing an auto bandwidth summary of all the trunks associated with auto bandwidth profile:

```
#show rsvp trunk auto-bandwidth
```

Trunk-Name	Trunk ID	LSP ID	Last BW	Requested BW	Signaled BW	Current BW	Highest BW	Adjust-Time Left (sec)	Last-Adjust Time
t1	5001	2201	10.1m	22.5m	22.5m	22.5m	35.5m	1142	2024 Jul 23

show rsvp trunk auto-bandwidth detail

Use this command to display the information of a trunk or all the trunks associated with the auto bandwidth profile. This command will provide detailed information of the auto bandwidth related statistics on the trunk as well as details of traffic rate samples collected in an adjust cycle and the time left for next sample collection, etc.

Command Syntax

```
show rsvp trunk auto-bandwidth (TRUNKNAME | detail)
```

Parameters

TRUNKNAME	Specifies the name of the particular trunk to display auto-bandwidth details for.
-----------	---

Command Mode

Exec mode and Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for viewing the auto bandwidth details of all the trunks associated with auto bandwidth profile

```
#show rsvp trunk auto-bandwidth detail
:Session: tl-Primary, Tunnel-id: 5001, LSP-ID: 2201, Egress: 2.2.2.2
```

```
-----
Sample Interval                : 5 minutes
Adjustment Interval            : 30 minutes
Minimum Samples required for processing : 1
Initialization Bandwidth      : 0
Minimum Bandwidth              : 0
Maximum Bandwidth              : 100m
Overflow Threshold Bandwidth   : 5m
Underflow Threshold Bandwidth  : 5m
Overflow Threshold Activate Bandwidth : 0
Underflow Threshold Activate Bandwidth : 0
Overflow Limit                 : 3
Underflow Limit                : 3
Max. Bandwidth Exceed Limit    : N/A
-----
```

```
Max-BW-exceed-limit action    : notify
Resignal-failure-action       : notify
Monitor Bandwidth             : No
-----
```

```
Minimum Average Bandwidth     : 0
Maximum Average Bandwidth     : 22.5m
Total Overflow Count           : 1
Consecutive Overflow Count     : 1
Consecutive Eligible Overflow Count : 1
Total Underflow Count         : 0
Consecutive Underflow Count    : 0
Consecutive Eligible Underflow Count : 0
Max. Bandwidth Exceed Count   : 0
Teardown Count                : 0
-----
```

```
Last Bandwidth                : 10.2m
Last Requested Bandwidth      : 15.6m
Last Signaled Bandwidth       : 15.6m
Current Bandwidth             : 15.6m
Highest Bandwidth             : 35.3m
-----
```

```
Time for Next Sample request   : 1 minutes, 20 seconds
Time for Next Adjustment      : 16 minutes, 30 seconds
Time of Last Bandwidth Request : 2024 Jul 23 11:32:44
Time of Last Bandwidth Signal  : 2024 Jul 23 11:32:44
Time of Last Adjustment        : 2024 Jul 23 11:32:44
Time of Highest Bandwidth Marked : 2024 Jul 23 11:14:37
-----
```

```
Total Auto-Bandwidth Adjustments : 2
```

Successful Adjustments : 2
Failed Adjustments : 0

Samples collected in the current adjustment cycle:
[Samples 1-5] : 17.5m 18.3m 22.5m

RSVP-TE Command Reference

CHAPTER 1 RSVP-TE Commands

This chapter describes the RSVP-TE commands.

- A.B.C.D
- ack-wait-timeout
- clear rsvp session
- clear rsvp trunk
- cspf
- debug rsvp all
- debug rsvp cspf
- debug rsvp events
- debug rsvp fsm
- debug rsvp hexdump
- debug rsvp nsm
- debug rsvp packet
- description (rsvp-bypass)
- description (rsvp-path)
- description (rsvp-trunk)
- disable-rsvp
- enable-rsvp
- entropy-label-capability
- explicit-null
- ext-tunnel-id A.B.C.D
- from A.B.C.D
- graceful-restart
- graceful-restart recovery-time
- graceful-restart restart-time
- hello-interval
- hello-receipt
- hello-timeout
- keep-multiplier
- loop-detection
- lsp-metric
- lsp-reoptimization-timer
- map-route A.B.C.D
- neighbor A.B.C.D

- neighbor X:X::X:X
- no cspf
- no igp-shortcut
- no loop-detection
- no php
- no record
- no refresh-path-parsing
- no refresh-resv-parsing
- path-option dynamic pce
- php
- primary ADMIN-GROUP-NAME
- primary affinity
- primary bandwidth
- primary cspf
- primary cspf-retry-limit
- primary cspf-retry-timer
- primary filter
- primary hold-priority
- primary hop-limit
- primary label-record
- primary local-protection
- no primary affinity
- no primary cspf
- no primary record
- primary path
- primary record
- primary retry-limit
- primary retry-timer
- primary reuse-route-record
- primary setup-priority
- primary traffic
- refresh-time
- refresh-path-parsing
- refresh-resv-parsing
- reoptimize
- restart rsvp graceful

- `revert-timer`
- `router rsvp`
- `rsvp hello-interval`
- `rsvp hello-receipt`
- `rsvp hello-timeout`
- `rsvp keep-multiplier`
- `rsvp refresh-time`
- `rsvp-path`
- `rsvp-trunk`
- `rsvp-trunk force-reoptimize`
- `rsvp-trunk force-switchover-secondary`
- `rsvp-trunk-restart`
- `secondary ADMIN-GROUP-NAME`
- `secondary bandwidth`
- `secondary cspf`
- `secondary cspf-retry-limit`
- `secondary cspf-retry-timer`
- `secondary filter`
- `secondary hold-priority`
- `secondary hop-limit`
- `secondary label-record`
- `secondary local-protection`
- `no secondary affinity`
- `no secondary cspf`
- `no secondary record`
- `secondary path`
- `secondary-priority path`
- `secondary-priority hold-priority`
- `secondary-priority setup-priority`
- `secondary-priority label-record`
- `secondary-priority hop-limit`
- `secondary-priority bandwidth`
- `secondary record`
- `secondary retry-limit`
- `secondary retry-timer`
- `secondary reuse-route-record`

- `secondary setup-priority`
- `secondary traffic`
- `shutdown`
- `snmp restart rsvp`
- `to A.B.C.D`
- `update-type`

A.B.C.D

Use this command to configure an explicit IPv4 route sub-object as either loose or strict. A list of sub-objects specifies an explicit route to the egress router for an LSP.

- For the strict type of route addresses, the route taken from the previous router to the current router must be a directly connected path and a message exchanged between the two routers should not pass any intermediate routers. This ensures that routing is enforced on the basis of each link. For configuring path-option as “strict” path, we need to configure interface ip address (ip address of next-hop interface). strict with loopback ip shall not be configured.
- For the loose type of route addresses, the route taken from the previous router to the current router need not be a direct path and a message exchanged between the two routers can pass other routers. For configuring path-option as “loose” path, we can configure either loopback interface ip address or next-hop interface ip address. It will expand the explicit path accordingly since the next hop need not to be a connected one.

Use the `no` parameter with this command to disable the configuration.

Command Syntax

```
A.B.C.D
A.B.C.D (loose|strict)
no A.B.C.D
no A.B.C.D (loose|strict)
```

Parameters

<code>loose</code>	Make this node loose
<code>strict</code>	Make this node strict

Default

By default, A.B.C.D is disabled

Command Mode

Path mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-path mypath
(config-path)#10.10.0.5 strict
```

ack-wait-timeout

Use this command to set the acknowledgement wait timeout for the RSVP daemon. This command can be invoked from config-router mode.

Use the `no` parameter with this command to revert to the default settings.

Command Syntax

```
ack-wait-timeout <1-65535>
no ack-wait-timeout
```

Parameters

<1-65535> Configure acknowledgement wait timeout.

Default

By default, `no ack-wait-timeout`.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 4.2.

Examples

```
#configure terminal
(config)router rsvp
(config-router)# ack-wait-timeout 30

#configure terminal
(config)router rsvp
(config-router)# no ack-wait-timeout
```

clear rsvp session

Use this command to reset either all or specified sessions originating from a specific ingress and terminating on the specific egress.

Note: If the affected session originates from the router where the command is issued, it is stopped and started. If the affected session does not originate from the router where the command is issued, it is stopped and deleted.

Command Syntax

```
clear rsvp session TUNNEL-ID LSP-ID INGRESS EGRESS
```

Parameters

TUNNELID	Clear tunnel ID sessions
LSP-ID	Clear LSP ID sessions
INGRESS	Clear ingress sessions
EGRESS	Clear egress sessions

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#clear rsvp session 1 1 1.2.3.4 192.168.1.1
```

clear rsvp trunk

Use this command to clear an RSVP trunk or to clear all RSVP trunks.

Clearing a trunk also kills any session associated with the trunk. This command is useful when a trunk is missing required data such as routing information. When data is missing, the trunk is in an incomplete state, and clearing it correctly re-initializes the session.

Note: If this command is given in the session on the ingress router, the session stops and restarts. If this command is given in the session on the egress router, the session is not cleared.

Command Syntax

Note: Use the following commands to clear standard RSVP Trunks:

```
clear rsvp trunk *
clear rsvp trunk ingress (TRUNKNAME|*)
clear rsvp trunk non-ingress (TRUNKNAME|*)
clear rsvp trunk (TRUNKNAME|*)
clear rsvp trunk (TRUNKNAME|*) primary
clear rsvp trunk (TRUNKNAME|*) secondary
```

Parameters

*	Clear all RSVP trunks configured
TRUNKNAME	Name of a specific trunk to be cleared
ingress	Clear an RSVP ingress trunk
non-ingress	Clear an RSVP non-Ingress trunk
primary	Clear all primary sessions configured for this trunk
secondary	Clear all secondary sessions configured for this trunk

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#clear rsvp trunk mytrunk
#clear rsvp trunk *
#clear rsvp trunk ingress mytrunk
#clear rsvp trunk ingress *
#clear rsvp trunk non-ingress mytrunk
#clear rsvp trunk non-ingress *
#clear rsvp trunk mytrunk primary
#clear rsvp trunk * primary
#clear rsvp trunk mytrunk secondary
#clear rsvp trunk * secondary
```

cspf

Use this command to enable the use of Constrained Shortest Path First (CSPF) server for all RSVP sessions. If CSPF is turned off globally, it cannot be enabled for any LSP.

The CSPF server computes paths for LSPs that are subject to various constraints such as bandwidth, hop count, administrative groups, priority, and explicit routes. When computing paths for LSPs, CSPF considers not only the topology of the network and the attributes defined for the LSP but also the links. It attempts to minimize congestion by intelligently balancing the network load.

Use the **no cspf** command to disable this configuration.

Note: CSPF server information is not signaled across session and hence sessions in transit and egress nodes will not be aware of the CSPF server. So, in multi CSPF scenarios, neighbor down event from a CSPF server restart all sessions irrespective of which CSPF server sessions were using.

Note: The CSPF server is unaware of whether an interface is label-switching and RSVP enabled. So, the LSP calculation may include non-RSVP interfaces too, and may lead to tunnel sessions not coming up. To avoid links that are not label-switching and RSVP enabled, “te-metric” with the highest value shall be configured on those interfaces to de-prioritize those links in the TE database.

Command Syntax

`cspf`

Parameters

None

Default

By default, CSPF server is enabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows using the **no cspf** command in Router mode to disable CSPF for all RSVP sessions.

```
#configure terminal
(config)#router rsvp
(config-router)#cspf
```

debug rsvp all

Use this command to enable all debugging options for an RSVP daemon.

Use the `no` parameter with this command to stop logging all debugging information.

Command Syntax

```
debug rsvp (all|)
no debug rsvp (all|)
```

Parameters

None

Command Mode

Privileged Exec mode and Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#debug rsvp all
```

debug rsvp cspf

Use this command to enable the exchange of debugging messages between the RSVP module and the CSPF module. Use the `no` parameter with this command to stop logging CSPF debugging information.

Command Syntax

```
debug rsvp cspf
no debug rsvp cspf
```

Parameters

None

Command Mode

Privileged Exec mode and Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#debug rsvp cspf
```

debug rsvp events

Use this command to enable debugging of events that were generated from an RSVP daemon.

Use the `no` parameter with this command to stop logging RSVP debugging information.

Command Syntax

```
debug rsvp events
no debug rsvp events
```

Parameters

None

Command Mode

Privileged Exec and Configure modes

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#debug rsvp events
```


debug rsvp fsm

Use these commands to enable debugging of events related to RSVP finite state machines (FSM). Commands are available to log debugging information for the egress FSM, the ingress FSM, the transit FSM, the transit upstream FSM, or the transit downstream FSM.

Use the `no` parameter with these commands to stop logging FSM debugging information.

Command Syntax

```
debug rsvp fsm
debug rsvp fsm egress
debug rsvp fsm ingress
debug rsvp fsm transit
debug rsvp fsm transit upstream
debug rsvp fsm transit downstream
no debug rsvp fsm
no debug rsvp fsm egress
no debug rsvp fsm ingress
no debug rsvp fsm transit
no debug rsvp fsm transit upstream
no debug rsvp fsm transit downstream
```

Parameters

None

Command Mode

Privileged Exec and Configure modes

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
(config)#debug rsvp fsm transit upstream
```

debug rsvp hexdump

Use this command to enable the hexdump debugging option for an RSVP daemon.

Use the `no` parameter with this command to stop logging hexdump debugging information.

Command Syntax

```
debug rsvp hexdump
no debug rsvp hexdump
```

Parameters

None

Command Mode

Privileged Exec and Configure modes

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#debug rsvp hexdump
```

debug rsvp nsm

Use this command to enable the NSM debugging option for an RSVP daemon.

Use the `no` parameter with this command to stop logging NSM debugging information.

Command Syntax

```
debug rsvp nsm
no debug rsvp nsm
```

Parameters

None

Command Mode

Privileged Exec and Configure modes

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#debug rsvp nsm
```

debug rsvp packet

Use this command to enable packet debugging options for an RSVP daemon. Using the `in` option command enables debugging for incoming packets. Using the `out` option command enables debugging for outgoing packets.

Use the `no` parameter with these commands to stop logging debugging information.

Command Syntax

```
debug rsvp packet
debug rsvp packet in
debug rsvp packet out
no debug rsvp packet
no debug rsvp packet in
no debug rsvp packet out
```

Parameters

None

Command Mode

Privileged Exec and Configure modes

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#debug rsvp packet in
#debug rsvp packet out
```

description (rsvp-bypass)

Use this command to add a description to the rsvp-bypass or update an existing description.

Use the `no` parameter with this command to disable the configuration.

Command Syntax

```
description LINE
no description
```

Parameters

LINE	Line describing the RSVP tunnel
------	---------------------------------

Default

By default, rsvp bypass description is empty.

Command Mode

Rsvp-bypass mode

Applicability

This command was introduced in OcNOS version 6.4.1.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#description this_is_the_description
(config-bypass)#no description
```

description (rsvp-path)

Use this command to add a description to the rsvp-path or update an existing description.

Use the `no` parameter with this command to disable the configuration.

Command Syntax

```
description LINE
no description
```

Parameters

LINE	Line describing the RSVP path
------	-------------------------------

Default

By default, rsvp path description is empty.

Command Mode

Rsvp-path mode

Applicability

This command was introduced in OcNOS version 6.4.1.

Examples

```
#configure terminal
(config)#rsvp-path mypath
(config-path)#description this_is_the_description
(config-path)#no description
```

description (rsvp-trunk)

Use this command to add a description to the rsvp-trunk or update an existing description.

Use the `no` parameter with this command to disable the configuration.

Command Syntax

```
description LINE
no description
```

Parameters

LINE	Line describing the RSVP tunnel
------	---------------------------------

Default

By default, rsvp trunk description is empty.

Command Mode

Rsvp-trunk mode.

Applicability

This command was introduced in OcNOS version 6.4.1.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#description this_is_the_description
(config-trunk)#no description
```

disable-rsvp

Use this command to disable RSVP message exchange on an interface.

RSVP can be enabled using the [enable-rsvp](#) command.

Command Syntax

```
disable-rsvp
```

Parameters

None

Default

By default, RSVP message exchange is disabled on an interface.

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#disable-rsvp
```


enable-rsvp

Use this command to enable RSVP message exchange on an interface.

Note: To use this command, the corresponding interface needs to be enabled for label-switching using the [label-switching](#) command.

See [disable-rsvp](#) to undo the effects of this command.

Command Syntax

```
enable-rsvp
```

Parameters

None

Default

By default, RSVP message exchange is disabled.

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth1
(config-if)#enable-rsvp
```

entropy-label-capability

Use this command to share the load across multiple members of a LAG port in the core of an MPLS network by using entropy labels.

Note: Use the `no` form of the command to disable the use of entropy labels

Command Syntax

```
entropy-label-capability
no entropy-label-capability
```

Parameters

None

Default

By default, entropy labels are not used.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 3.0.

Examples

```
#configure terminal
(config)router rsvp
(config-router)#entropy-label-capability
```

explicit-null

Use this command to send explicit-null labels to upstream router, instead of implicit-null labels.

If php is enabled then implicit-null label is advertised, then the penultimate hop removes the label and sends the packet as a plain IP packet to the egress router. The explicit-null command advertises label 0 and retains the label so the egress router can pop it. For details about usage of explicit-null, please refer to *RFC 3032*.

Use the `no` parameter with this command to stop sending explicit-null labels for directly-connected FECs to upstream router and resume sending non reserved labels.

Command Syntax

```
explicit-null
no explicit-null
```

Parameters

None

Default

By default, no php is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#explicit-null
```

ext-tunnel-id A.B.C.D

Use this command to configure an extended-tunnel identifier as an IPv4 address. These identifiers are used in RSVP messages. If no extended-tunnel ID is specified, the LSR-ID for the router is used as the extended-tunnel ID for all LSPs. The extended-tunnel ID is a simple way of identifying all LSPs belonging to the same trunk.

Use the `no` parameter with this command to remove a configured extended-tunnel ID.

Command Syntax

```
ext-tunnel-id A.B.C.D
no ext-tunnel-id
```

Parameters

A.B.C.D	Extended tunnel identifier for this trunk in IPv4 address format
---------	--

Default

By default, the LSR-ID of the router is used as the extended-tunnel ID for all sessions.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk t1
(config-trunk)#ext-tunnel-id 10.10.10.30

(config)#rsvp-trunk t1
(config-trunk)#no ext-tunnel-id
```

from A.B.C.D

Use this command to specify a “from” IPv4 address for the RSVP daemon. This command can be invoked from either the [router rsvp](#) mode or from the [rsvp-trunk](#) mode. In the RSVP router mode, this command defines the source address as an IPv4 packet sent out by the RSVP daemon. In the RSVP trunk mode, this command indicates a sender’s address in the sender template object that is used in path messages.

Use the `no` parameter with this command to revert to the default settings.

Command Syntax

```
from A.B.C.D
no from
```

Parameters

A.B.C.D	When in trunk mode, this is the IPv4 address of a tunnel ingress node
A.B.C.D	When in router mode, this is the loopback IPv4 address

Default

By default, from A.B.C.D is enabled

Command Mode

Router or Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#from 10.10.0.5

#configure terminal
(config)#router rsvp
(config-router)#from 10.10.0.5
```

graceful-restart

Use this command to enable RSVP-TE graceful restart capability on a router. This is a global parameter. RSVP-TE determines whether or not to send the graceful restart capability object in its hello message. However, this capability also depends on support for graceful restart on the neighbor router.

The following conditions must be met in order to activate RSVP-TE graceful restart:

- This command is used on the local router.
- The neighbor router is explicitly set with either the [entropy-label-capability](#) or [neighbor X:X::X:X](#) command.
- The neighbor router supports graceful restart, and it is activated.

Command Syntax

```
graceful-restart
no graceful-restart
```

Parameters

None

Default

Graceful restart is disabled by default.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 5.0.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#graceful-restart
(config-router)#no graceful-restart
```

graceful-restart recovery-time

Use this command to set a recovery time for an RSVP-TE graceful restart configuration.

Use the `no` parameter with this command to reset the recovery time.

Command Syntax

```
graceful-restart recovery-time <60000-3600000>  
no graceful-restart recovery-time
```

Parameters

<60000-3600000> Recovery time value in milliseconds

Default

Default value is 360000 ms.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 5.0.

Examples

```
#configure terminal  
(config)#router rsvp  
(config-router)#graceful-restart recovery-time 600000
```

graceful-restart restart-time

Use this command to set a restart time for an RSVP-TE graceful restart configuration.

Use the `no` parameter with this command to reset the restart time.

Command Syntax

```
graceful-restart restart-time <10000-600000>  
no graceful-restart restart-time
```

Parameters

<10000-600000> Restart time value in milliseconds

Default

Default value is 180000 ms.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 5.0.

Examples

```
#configure terminal  
(config)#router rsvp  
(config-router)#graceful-restart restart-time 100000
```


hello-interval

Use this command to set an interval between Hello packets.

Used as a global command, this value is over-ridden by the hello-interval set on the interface (see [rsvp hello-interval](#)). For optimum performance, set this value no more than one-third of the hello-timeout value.

Use the `no` parameter with this command to return to the default hello interval value.

Command Syntax

```
hello-interval <1-65535>
no hello-interval
```

Parameter

<code><1-65535></code>	The time in seconds after which hello packets are sent
------------------------------	--

Default

By default, hello interval is 2 seconds

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#hello-interval 5

(config)#router rsvp
(config-router)#no hello-interval
```

hello-receipt

Use this command to enable the receipt of Hello messages from peers.

Use the `no` parameter with this command to disable the exchange of Hello messages.

Command Syntax

```
hello-receipt
no hello-receipt
```

Parameters

None

Default

By default, hello receipt is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#hello-receipt
```

hello-timeout

Use this command to set the RSVP hello timeout. If an LSR has not received a hello message from a peer within the number of seconds set with this command, all sessions shared with this peer are reset. The hello-timeout determines how long an RSVP node waits for a hello message before declaring a neighbor to be down.

Use the `no` parameter with this command to set the default hello timeout value.

Command Syntax

```
hello-timeout <1-65535>
no hello-timeout
```

Parameter

`<1-65535>` Time in seconds to receive a hello message.

Default

By default, hello-timeout value is 7 seconds.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#hello-timeout 12

(config)#router rsvp
(config-router)#no hello-timeout
```

keep-multiplier

Use this command to configure the constant to be used to calculate a valid reservation lifetime for a Labeled Switched Path (LSP).

The refresh time and keep multiplier are two interrelated timing parameters used to calculate the valid reservation lifetime for an LSP. Use the following formula to calculate the reservation lifetime for an LSP:

$$L \geq (K + 0.5) * 1.5 * R$$

K = keep-multiplier
 R = refresh timer

The router sends refresh messages periodically so that the neighbors do not timeout.

Use the `no` parameter with this command to return to the default keep-multiplier setting.

Command Syntax

```
keep-multiplier <1-255>
no keep-multiplier <1-255>
```

Parameters

`<1-255>` The keep-multiplier value

Default

By default, keep-multiplier value is 3

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#keep-multiplier 2
```

loop-detection

Use this command to turn on loop detection for Path and Reservation messages exchanged between LSRs.

Use the [no loop-detection](#) command to return to default settings.

Command Syntax

```
loop-detection
```

Parameters

None

Default

By default, loop detection is enabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#loop-detection
```

lsp-metric

Use this command to set LSP absolute metric or relative metric for IGP Shortcut use

Use the `no` parameter along with this command to unset the LSP metric for IGP shortcut.

Command Syntax

```
lsp-metric absolute <1-65535>
lsp-metric relative (<-65535-0>|<1-65535>)
no lsp-metric absolute (<1-65535>|)
no lsp-metric relative (<-65535-0>|<1-65535>|)
```

Parameters

<code>absolute</code>	Absolute metric
<code>relative</code>	Relative metric
<code><1-65535></code>	Metric value
<code><-65535-0></code>	The keep-multiplier value

Command Mode

RSVP Trunk mode

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#exit
(config)#rsvp-trunk T1
(config-trunk)#lsp-metric absolute 10
(config-trunk)#lsp-metric relative 10
```

lsp-reoptimization-timer

Use this command to set the re-optimization interval timer.

Use the no parameter with this command to set the default re-optimization interval (5 minutes).

Command Syntax

```
lsp-reoptimization-timer <1-240>
```

Parameter

<1-240> The interval in minutes after which LSP re-optimization will take place.

Default

By default, the re-optimization timer interval is 5 minutes.

Command Mode

RSVP router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
(config)#router rsvp
(config-router)#lsp-reoptimization-timer 10
(config)#router rsvp
(config-router)#no lsp-reoptimization-timer
```

map-route A.B.C.D

Use this command to map a route using an IPv4 to an RSVP trunk. If the primary LSP for a trunk goes down, all mapped routes are sent automatically to a secondary LSP configured as backup for a primary LSP.

Use the `no` parameter with this command to unmap routes from specified trunks.

Command Syntax

```
map-route A.B.C.D/M
map-route A.B.C.D/M CLASS
map-route A.B.C.D A.B.C.D
map-route A.B.C.D A.B.C.D CLASS
no map-route A.B.C.D/M
no map-route A.B.C.D/M CLASS
no map-route A.B.C.D A.B.C.D
no map-route A.B.C.D A.B.C.D CLASS
```

Parameters

A.B.C.D/M	Prefix to map, plus mask
A.B.C.D	Prefix to be mapped
A.B.C.D	Prefix mask
CLASS	Incoming DiffServ Class (for example, be, ef, etc.) to map to the RSVP trunk

Default

By default, map route A.B.C.D/M is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#map-route 2.2.2.2/16
```


neighbor A.B.C.D

Use this command to designate a neighbor IPv4 address to use when exchanging hello messages. Any neighbor hello message that is not explicitly identified is rejected.

Use the `no` parameter with this command to remove an IP neighbor from the system.

Command Syntax

```
neighbor A.B.C.D
no neighbor A.B.C.D
```

Parameters

None

Default

By default, neighbor A.B.C.D is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#neighbor 10.10.0.5
```

neighbor X:X::X:X

Use this command to designate a neighbor IPv6 address to use when exchanging hello messages. Any neighbor hello message that is not explicitly identified is rejected.

Use the `no` parameter with this command to remove an IP neighbor from the system.

Command Syntax

```
neighbor X:X::X:X  
no neighbor X:X::X:X
```

Parameters

None

Default

By default, neighbor X:X::X:X is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal  
(config)#router rsvp  
(config-router)#neighbor 3ffe::3:34
```

no cspf

Use this command to disable the use of the Constrained Shortest Path First (CSPF) server for all RSVP sessions. Disable CSPF when no nodes support the required traffic engineering extensions.

When this command is executed in Router mode, CSPF is disabled for all configured RSVP sessions, and all RSVP sessions configured from this point forward. If the default CSPF per RSVP session is enabled, it will be disabled. The CSPF status for RSVP sessions can be verified using the [show rsvp session](#) command with the detail option.

Use the [cspf](#) command to revert to the default settings.

Note: When CSPF is disabled, path is not calculated taking constraints into consideration. Path message is sent to the next hop based on IGP best route. In this case, ERO is not included in path message and all constraints are included.

Command Syntax

```
no cspf
```

Parameters

None

Default

By default, no cspf is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows using the `no cspf` command in Router mode to disable CSPF for all RSVP sessions.

```
#configure terminal
(config)#router rsvp
(config-router)#no cspf
```

no igp-shortcut

Use this command to disable Interior Gateway Protocol (IGP) shortcut.

Command Syntax

```
no igp-shortcut
```

Parameters

None

Command Mode

Trunk mode

Example

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no igp-shortcut
```

no loop-detection

Use this command to turn off loop detection for Path and Reservation messages exchanged between LSRs. When a Path or Resv message is received, the primary IP address of the incoming interface is compared with the received route record list.

Use the [loop-detection](#) command to revert to default settings.

Command Syntax

```
no loop-detection
```

Parameters

None

Default

By default, no loop detection is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#no loop-detection
```

no php

Use this command to disable Penultimate-Hop-Popping (PHP) for the router. An egress router sends neither implicit null label nor explicit null for LSPs. When `no php` command is used, the egress router sends non-reserved labels (those labels in the label pool range allotted to RSVP) to the upstream router and retains the labels till the egress router.

Note: Use the [show rsvp](#) command to display the status of Penultimate-Hop-Popping.

Command Syntax

```
no php
```

Parameters

None

Default

By default, no php is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#no php
```

no record

Use this command to disable recording of the route taken by Path and Reservation Request (Resv) messages that confirm establishment of reservations and are used to identify errors. The routes are recorded by means of the Route Record Object (RRO) in RSVP messages.

Command Syntax

```
no record
```

Parameters

None

Default

Routes are recorded by default.

Command Mode

RSVP Bypass mode

Examples

```
#configure terminal
(config)#rsvp-bypass bypassname
(config-bypass)#no record
```

no refresh-path-parsing

Use this command to disable parsing of Refresh PATH messages received from upstream nodes. Enable this command to minimize message processing by RSVP, if you are sure that a particular router does not need to parse Refresh-PATH messages to check for changes because LSPs passing through this router are not required to be updated, simultaneously.

Use the [refresh-path-parsing](#) command to revert to the default settings.

Command Syntax

```
no refresh-path-parsing
```

Parameters

None

Default

By default, refresh-path-parsing is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
Router#configure terminal
Router(config)#router rsvp
Router(config-router)#no refresh-path-parsing
```


no refresh-resv-parsing

Use this command to disable parsing of Refresh RESV messages received from upstream nodes. Enable this command to minimize message processing by RSVP, if you are sure that a particular router does not need to parse Refresh RESV messages to check for changes because LSPs passing through this router are not required to be updated simultaneously.

Command Syntax

```
no refresh-resv-parsing
```

Parameters

None

Default

By default, refresh reservation parsing is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
Router#configure terminal
Router(config)#router rsvp
Router(config-router)#no refresh-resv-parsing
```

path-option dynamic pce

Use this command to indicate that a tunnel must query PCE for path computation.

Command Syntax

```
path-option dynamic pce
```

Parameters

None

Command Mode

RSVP trunk mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#rsvp-trunk mytrunk ipv4
(config-trunk)#path-option dynamic pce
(config-trunk)#pce entity 1
```

php

Use this command to enable Penultimate-Hop-Popping for the router. An egress router send an implicit-null label (3) to the upstream router.

Note: Use the [show rsvp](#) command to display the status of Penultimate-Hop-Popping.

Use the [no php](#) command to revert to the default setting.

Note: On Qumran1 (QAX, QMX, and QUX) platforms, when a primary session has non-implicit-null out label and a backup session has implicit-null out label, then L3 services do not work when the session is at backup state. i.e., mpls ping, L3 ping, and map route traffic will fail as label popped packets cannot select the next header ethertype properly.

Command Syntax

php

Parameters

None

Default

By default, no php is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#php
```

primary ADMIN-GROUP-NAME

Use this command to configure primary administrative groups. Administrative groups are manually assigned attributes that describe the color of links, so that links with the same color are in one class. These groups are used to implement different policy-based LSP setups. Administrative group attributes can be included or excluded for an LSP or for a path's primary and secondary paths.

Note: A link can be added to a specific Administrative Group via the Network Services Module. Refer to the *Network Services Module Command Reference* for details.

Use the `no` parameter to remove a previously configured group from an administrative group list.

Command Syntax

```
primary (include-any|include-all|exclude-any) ADMIN-GROUP-NAME
primary (include-any|exclude-any) ADMIN-GROUP-NAME
primary (include-any|include-all|exclude-any) ADMIN-GROUP-NAME
primary (include-any|exclude-any) ADMIN-GROUP-NAME
```

Parameters

<code>include-any</code>	Include any attributes
<code>include-all</code>	Include all attributes
<code>exclude-any</code>	Exclude any attribute
<code>ADMIN-GROUP-NAME</code>	Administrative group name

Default

By default, primary admin group name is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary exclude-any myadmingroup

#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary include-all admingrp2

#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary include-any admingrp2
```

primary affinity

Use this command to enable sending of session attribute objects with resource affinity data.

Use the [no primary affinity](#) command to disable sending of session attribute objects.

Command Syntax

```
primary affinity
```

Parameters

None

Default

By default, primary affinity is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary affinity
```

primary bandwidth

Use this command to reserve the primary bandwidth in bits per second for the current trunk.

Each LSP has an associated bandwidth attribute. The bandwidth value is included in the sender's RSVP Path message and specifies the bandwidth to be reserved for the LSP. It is specified in bits per second, with a higher value indicating a greater user traffic volume. A zero bandwidth reserves no resources, although exchanges labels.

Use the `no` parameter to remove configured bandwidth information.

Command Syntax

```
primary bandwidth BANDWIDTH
no primary bandwidth BANDWIDTH
```

Parameter

BANDWIDTH	<1-999>k for 1 to 999 kilobits/s
	<1-999>m for 1 to 999 megabits/s
	<1-100>g for 1 to 100 gigabits/s

Default

The default bandwidth is 0 bits per second, which allows data to flow through but does not reserve bandwidth.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary bandwidth 100m
```

primary cspf

Use this command to enable the use of Constrained Shortest Path First (CSPF) server for an explicit route to the egress, or all RSVP sessions. When CSPF is turned off globally, it cannot be enabled for any LSP.

The CSPF server computes paths for LSPs that are subject to constraints such as bandwidth, hop count, administrative groups, priority, and explicit routes. When computing paths for LSPs, CSPF considers not only the topology of the network and the attributes defined for the LSP, but also the links. It attempts to minimize congestion by intelligently balancing the network load.

Use the [no primary affinity](#) command to revert to the default settings.

Note: CSPF server information is not signaled across session and hence sessions in transit and egress nodes will not be aware of the CSPF server. So, in multi CSPF scenarios, neighbor down event from a CSPF server restart all sessions irrespective of which CSPF server sessions were using.

Command Syntax

```
primary cspf
```

Parameters

None

Default

By default, primary cspf is enabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary cspf
```

primary cspf-retry-limit

Use this command to specify the number of retries that CSPF should carry out for a request received from RSVP.

Use the `no` parameter with this command to disable this configuration.

Command Syntax

```
primary cspf-retry-limit <1-65535>
no primary cspf-retry-limit
```

Parameter

<1-65535>	Set the number of times CSPF should retry for this LSP
-----------	--

Default

By default, retry-limit is 0.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary cspf-retry-limit 535

(config)#rsvp-trunk T1
(config-trunk)#no primary cspf-retry-limit
```


primary cspf-retry-timer

Use this command to specify the time between each retry that CSPF might carry out for a request received from RSVP. Use the `no` parameter with this command to disable this configuration.

Command Syntax

```
primary cspf-retry-timer <1-600>
no primary cspf-retry-timer
```

Parameter

<1-600>	Timeout between successive retries, in seconds
---------	--

Default

By default, retry-timer is 0

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary cspf-retry-timer 45

(config)#rsvp-trunk T1
(config-trunk)#no primary cspf-retry-timer
```

primary filter

Use this command to set the filter to the fixed or shared style for an LSP.

- The shared filter style identifies a shared reservation environment. It creates a single reservation into which flows from all senders are mixed.
- The fixed filter style designates a distinct reservation. A distinct reservation request is created for data packets from a particular sender. The fixed filter style is also used style to prevent rerouting of an LSP and to prevent another LSP from using this bandwidth.

Use the `no` parameter to reset the configured filter to the default.

Command Syntax

```
primary filter fixed
no primary filter
```

Parameters

<code>fixed</code>	Use a fixed filter for this LSP
--------------------	---------------------------------

Default

By default, primary filter is shared-explicit.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary filter fixed
```

primary hold-priority

Use this command to configure the hold priority value for the selected trunk. In case of insufficient bandwidth, remove less important existing LSPs to free up a portion of the bandwidth. This can be done by preempting one or more of the signaled LSPs. Hold priority determines the degree to which an LSP holds onto its reservation for a session after the LSP has been configured successfully. When the hold priority is high, the existing LSP is less likely to give up its reservation.

Use the `no` parameter to reset the trunk to the default hold-priority value.

Command Syntax

```
primary hold-priority <0-7>
no primary hold-priority
```

Parameter

<0-7>	Set a hold priority for the LSP
-------	---------------------------------

Default

The default hold-priority value is 0, which is the highest. Once a session is configured with a hold priority of 0, no other session can preempt it.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary hold-priority 2
```

primary hop-limit

Use this command to specify a limit of hops for an RSVP trunk. Hop-limit data is sent to the CSPF server if CSPF is used.

Upon configuration of an arbitrary hop-limit, the hop-limit is compared with the number of hops configured in the primary path, if a primary path has been configured. If the number of hops in the primary path exceeds the hop-limit configured, no `Path` messages are sent, and any existing session is torn down. If no primary path is configured, the trunk is processed normally and `Path` messages are sent.

Use the `no` parameter to reset the trunk to the default hop-limit value.

Command Syntax

```
primary hop-limit <1-255>
no primary hop-limit <1-255>
no primary hop-limit
```

Parameters

<1-255>	Set the number of acceptable hops for the LSP
---------	---

Default

By default, primary hop limit is 255

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary hop-limit 23
```

primary label-record

Use this command to record all labels exchanged between RSVP-enabled routers during the reservation setup process.

Use the `no` parameter with this command to turn off recording.

Command Syntax

```
primary label-record  
no primary label-record
```

Parameters

None

Default

By default, primary label record is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal  
(config)#rsvp-trunk mytrunk  
(config-trunk)#primary label-record
```

primary local-protection

Use this command to enable the local repair of explicit routes for which this router is a transit node.

Use the `no` parameter with this command to disable local repair of explicit routes.

Command Syntax

```
primary local-protection
no primary local-protection
```

Parameters

None

Default

By default, primary local protection is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary local-protection
```

no primary affinity

Use this command to disable the use of sending out session attribute objects with resource affinity data.

Use the [primary affinity](#) command to return to the default settings.

Command Syntax

```
no primary affinity
```

Parameters

None

Default

By default, primary no affinity is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no primary affinity
```

no primary cspf

Use this command to disable the use of Constrained Shortest Path First (CSPF) server for an explicit route to the egress, or all RSVP sessions. When CSPF is turned off globally it cannot be enabled for any LSP. If used per LSP, it can be used to turn off CSPF computation for a specific LSP.

Disable CSPF when all nodes do not support the required traffic engineering extensions, and configure LSPs manually to use an explicit path. The LSP is then established only along the path specified by the operator.

Use the [primary cspf](#) command to enable this setting.

Command Syntax

```
no primary cspf
```

Parameters

None

Default

By default, no primary cspf is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows using the `no cspf` command in Trunk mode to disable CSPF for the primary LSP.

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no primary cspf
```


no primary record

Use this command to disable recording of the route taken by Path and Reservation Request (Resv) messages to confirm establishment of reservations and identify errors. Routes are recorded by means of the Route Record Object (RRO) in RSVP messages.

Use the [primary record](#) command to return to the default settings.

Command Syntax

```
no primary record
```

Parameters

None

Default

By default, routes are recorded

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no primary record
```

primary path

Use this command to specify an RSVP path to be used. The `PATHNAME` in this command is the string (name) used to identify an RSVP path defined for the node (refer to `rsvp-path` command).

Use the `no` parameter with this command to remove a configured RSVP path.

Command Syntax

```
primary path PATHNAME
no primary path
```

Parameters

<code>PATHNAME</code>	The name of the path to use
-----------------------	-----------------------------

Default

By default, primary path is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary path mypath
```

primary record

Use this command to enable recording of the route taken by Path and Reservation Request (Resv) messages to confirm establishment of reservations and identify errors. Routes are recorded by means of the Route Record Object (RRO) in RSVP messages.

Use the [no primary record](#) command to disable recording of routes.

Command Syntax

```
primary record
```

Parameters

None

Default

By default, routes are recorded

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary record
```

primary retry-limit

Use this command to specify a retry count this RSVP Trunk.

If a session is in a `nonexistent` state due to a path error message, the system tries to recreate the LSP for the number of times specified by the `retry-limit` command.

Although the same retry command controls both the trunk and the session, the `retry-limit` value affects only the session and not the trunk. If the trunk is in an `incomplete` state, the code keeps trying forever to bring it to a `complete` state regardless of the `retry-limit` value.

Use the `no` parameter with this command to revert to the default `retry-limit` value.

Command Syntax

```
primary retry-limit <1-65535>
no primary retry-limit
```

Parameter

<code><1-65535></code>	The set number of times the system should try setting up the LSP
------------------------------	--

Default

By default, the `retry-limit` value is 0, and the trunk and session try to create the LSP indefinitely.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary retry-limit 256
```

primary retry-timer

Use this command to specify a retry interval for an RSVP Trunk. When an ingress node tries to configure an LSP and the setup fails due to the receipt of a Path Error message, the system waits for the time configured with this command, before retrying the LSP setup process.

Use the `no` parameter with this command to revert to the default retry-time value.

Command Syntax

```
primary retry-timer <1-600>
no primary retry-timer
```

Parameter

<code><1-600></code>	Time in seconds after which the system should retry setting up the LSP
----------------------------	--

Default

By default, retry-timer value is 30 seconds.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary retry-timer 12
```

primary reuse-route-record

Use this command to use the updated Route Record List as an Explicit Route (with all strict nodes) when a path message is sent out at the next refresh.

The ERO list contains the hops to be taken to reach the egress from the current LSR. If CSPF is not available, to place an ERO with all strict routes, use this command to modify the ERO after receiving the Resv message. The future Path messages have the ERO with all strict nodes, identifying each and every node to be traversed.

Use the `no` parameter with this command to disable the use of the Route Record List as the explicit route.

Command Syntax

```
primary reuse-route-record
no primary reuse-route-record
```

Parameters

None

Default

By default, primary reuse route record is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary reuse-route-record
```

primary setup-priority

Use this command to configure a setup priority value for a trunk. In case of insufficient bandwidth, users must remove less important LSPs to free up the bandwidth. This can be done by preempting one or more of the existing LSPs. The primary setup priority determines if a new LSP can preempt an existing LSP.

The setup priority of the new LSP must be higher than the hold priority of an existing LSP for the existing LSP to be preempted. Note that for a trunk, the setup priority should not be higher than the hold priority.

Use the `no` parameter with this command to revert to the default primary setup priority value.

Command Syntax

```
primary setup-priority <0-7>
no primary setup-priority
```

Parameters

<0-7>	Set the priority value
-------	------------------------

Default

By default, setup priority is 7, which is the lowest.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary setup-priority 2
```

primary traffic

Use this command to specify the traffic type for this RSVP Trunk.

Use the `no` parameter with this command to reset the configured traffic type.

Command Syntax

```
primary traffic (guaranteed|controlled-load)
no primary traffic
```

Parameters

<code>controlled-load</code>	Controlled loaded traffic
<code>guaranteed</code>	Guaranteed traffic

Default

By default, primary traffic type is controlled-load

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary traffic guaranteed
```


refresh-time

Use this command to configure RSVP refresh interval timer. The timer specifies the interval after which Path and/ or Reservation Request (Resv) messages will be sent out.

The refresh time and keep multiplier are two interrelated timing parameters used to calculate the valid Reservation Lifetime for an LSP. Refresh time regulates the interval between Refresh messages which include Path and Reservation Request (Resv) messages. Refresh messages are sent periodically so that reservation does not timeout in the neighboring nodes. Each sender and receiver host sends Path and Resv messages, downstream and upstream respectively, along the paths.

Use the `no` parameter with this command to return to the default refresh-time interval.

Command Syntax

```
refresh-time <1-65535>
no refresh-time <1-65535>
no refresh-time
```

Parameter

`<1-65535>` The duration for which messages are sent, in seconds

Default

By default, refresh-time interval is 30 seconds

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#refresh-time 20
```

refresh-path-parsing

Use this command to disable parsing of Refresh PATH messages received from upstream nodes. Use this command to minimize message processing by RSVP when you are sure that a particular router does not need to parse Refresh-PATH messages to check for changes, because LSPs passing through this router are not required to be updated simultaneously.

Use the [no refresh-path-parsing](#) command to disable this setting.

Command Syntax

```
refresh-path-parsing
```

Parameters

None

Default

By default, refresh-path-parsing is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
Router#configure terminal
Router(config)#router rsvp
Router(config-router)#refresh-path-parsing
```

refresh-resv-parsing

Use this command to disable parsing of Refresh RESV messages received from upstream nodes. Use this command to minimize message processing by RSVP when you are sure that a particular router does not need to parse Refresh RESV messages to check for changes because LSPs passing through this router are not required to be updated simultaneously.

Use the [no refresh-resv-parsing](#) command to disable this setting.

Command Syntax

```
refresh-resv-parsing
```

Parameters

None

Default

By default, refresh reservation parsing is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
Router#configure terminal
Router(config)#router rsvp
Router(config-router)#refresh-resv-parsing
```

reoptimize

Use this command to enable re-optimization of the RSVP primary LSP with the [rsvp-trunk force-reoptimize](#) command. Use the no parameter with this command to disable re-optimization of the RSVP primary LSP.

Command Syntax

```
reoptimize
```

Parameters

None

Command Mode

Trunk mode

Applicability

This command was introduced in OcNOS version 1.3.4.

Examples

```
(config)#rsvp-trunk t1
(config-trunk)#reoptimize
(config)#rsvp-trunk t1
(config-trunk)#no reoptimize
```

restart rsvp graceful

Use this command to restart RSVP gracefully.

To restart RSVP gracefully, you must give the [graceful-restart](#) command to enable graceful restart capability on the device in RSVP router mode.

Command Syntax

```
restart rsvp graceful
```

Parameter

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#restart rsvp graceful
#restart rsvp graceful
% Warning : RSVP process will stop and needs to restart manually,
You may loose ospf configuration, if not saved
Proceed for graceful restart? (y/n):y
```

revert-timer

Use this command to specify a "revert-timer" for the RSVP daemon. This command can be invoked from either the router rsvp mode or from the rsvp-trunk mode. In the RSVP router mode, this command defines the revert timer from secondary session to primary session for the RSVP daemon.

Use the `no` parameter with this command to revert to the default settings.

Command Syntax

```
revert-timer <1-65535>
no revert-timer (<1-65535>|)
```

Parameters

<1-65535>	Hold-on timer before revert back to primary session
-----------	---

Default

By default, `no revert-timer` is configured

Command Mode

Router or Trunk mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#revert-timer 30

#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no revert-timer

#configure terminal
(config)#router rsvp
(config-router)#revert-timer 40
#configure terminal
(config)#router rsvp
(config-router)#no revert-timer
```

router rsvp

Use this command to enter router mode from configure mode and to enable the RSVP daemon, if it is not already enabled.

Use the `no` parameter with this command to disable RSVP on the node.

Command Syntax

```
router rsvp
no router rsvp
```

Parameters

None

Default

RSVP is started only if this command is executed.

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The command prompt changes from config to config-router, as illustrated below:

```
#configure terminal
(config)#router rsvp
(config-router)#

(config-router)#exit
(config)#no router rsvp
```

rsvp hello-interval

Use this command to enable the sending of Hello packets on the interface and to set the interval value between successive Hello packets to neighbor. For optimum performance, set this value to less than one-third the value of the configured RSVP hello-timeout. See the [rsvp hello-timeout](#) command for more information.

Note: This is an interface-specific command and when not used, the global hello-interval state applies.

Use the `no` parameter with this command to return to the default hello interval value.

Command Syntax

```
rsvp hello-interval <1-65535>
no rsvp hello-interval
```

Parameter

<1-65535>	RSVP hello interval in seconds
-----------	--------------------------------

Default

By default, RSVP hello interval is 2 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp hello-interval 110

(config)#interface eth0
(config-if)#no rsvp hello-interval
```


rsvp hello-receipt

Use this command to enable the receipt of hello messages from peers connected through this interface. This is an interface-specific command and when not used, the global [hello-receipt](#) command applies.

Use the `no` parameter with this command to disable the exchange of hello messages for this interface.

Command Syntax

```
rsvp hello-receipt
no rsvp hello-receipt
```

Parameters

None

Default

By default, rsvp hello receipt is disabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp hello-receipt
```

rsvp hello-timeout

This command determines how long an RSVP node should wait for a hello message before declaring a neighbor to be down. If an LSR does not received a hello message from a peer connected to an interface within the specified duration, the LSR resets all sessions that are shared with this particular peer. This is an interface-specific command and when not used, the global [hello-timeout](#) command applies.

Use the `no` parameter to revert to the default hello timeout value.

Command Syntax

```
rsvp hello-timeout <1-65535>
no rsvp hello-timeout
```

Parameters

<1-65535>	Time to receive a hello message, in seconds
-----------	---

Default

By default, hello-timeout value is 7 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp hello-timeout 550

(config)#interface eth0
(config-if)#no rsvp hello-timeout
```

rsvp keep-multiplier

This command sets the constant for calculating a valid reservation lifetime for an LSP, which allows messages to be exchanged through this interface. This is an interface-specific command and when not specified, the global [keep-multiplier](#) command applies.

Reservation lifetime is the duration of bandwidth reservation for the LSP. The refresh time and keep multiplier are two interrelated timing parameters used to calculate the valid reservation lifetime for an LSP. Use the following formula to calculate the reservation lifetime for an LSP:

$$L \geq (K + 0.5) * 1.5 * R$$

K = keep-multiplier
 R = refresh timer

Refresh messages are sent periodically so that neighbors do not timeout.

Use the `no` parameter with this command to return to the global keep-multiplier value.

Command Syntax

```
rsvp keep-multiplier <1-255>
no rsvp keep-multiplier <1-255>
```

Parameter

`<1-255>` Set a value for the lifetime constant

Default

By default RSVP keep-multiplier value is 3

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp keep-multiplier 3

(config)#interface eth0
(config-if)#no rsvp keep-multiplier
```

rsvp refresh-time

Use this command to configure RSVP refresh interval timer for the current interface. This is an interface-specific command and when not used, the global [refresh-time](#) command applies.

The refresh time and keep multiplier are two interrelated timing parameters used to calculate the valid reservation lifetime for an LSP. Refresh time regulates the interval between refresh messages that include path and reservation request (Resv) messages. Refresh messages are sent periodically so that the reservation does not timeout in the neighboring nodes. Each sender and receiver host sends path and resv messages, downstream and upstream respectively, along the paths.

Use the `no` parameter with this command to revert to the refresh-time value set in RSVP mode.

Command Syntax

```
rsvp refresh-time <1-65535>
no rsvp refresh-time <1-65535>
```

Parameter

<1-65535>	The duration for which messages are sent, in seconds
-----------	--

Default

By default, refresh interval is 30 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp refresh-time 5055

(config)#interface eth0
(config-if)#no rsvp refresh-time
```

rsvp-path

Use this command to create a new RSVP path or to enter the `Path` command mode. In this mode, you can add or delete paths and also specify the path to be loose or strict.

Use the `no` parameter with this command to delete the path and its specified hops.

Command Syntax

```
rsvp-path PATHNAME mpls
no rsvp-path PATHNAME
```

Parameter

PATHNAME	Name of the path
mpls	Type of the path

Default

By default, rsvp path is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3 and modified in OcNOS version 6.5.3.

Example

```
#configure terminal
(config)#rsvp-path mypath mpls
(config-path)#
```

rsvp-trunk

Use this command to create a new RSVP trunk. When the trunk is created, the attributes required to configure an explicitly-routed or traditionally-routed LSP are set. Once a trunk is configured with the required attributes, an RSVP session (and PSB) is created for this trunk, which enables the exchange of messages and completes the LSP setup.

This command also modifies an existing RSVP path to configure an explicitly-routed or traditionally-routed LSP. In addition, this command can be used to set the address family (IPv4) of an RSVP trunk. If no address family is assigned, the default value is used. If the address family is already set, a check is made to see whether the address family configured and the one already in the database are the same. An error message is returned if the two do not match.

Use the `no` parameter with this command to remove an RSVP trunk and all configured attributes, except the primary path.

Note: The RSVP trunk's name (`TRUNKNAME`) is limited to 32 characters.

Command Syntax

```
rsvp-trunk TRUNKNAME ipv4
no rsvp-trunk TRUNKNAME
```

Parameters

TRUNKNAME	Name to use for the trunk
ipv4	IPv4 address family trunk

Default

By default, rsvp trunk is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The command prompt changes from `config` to `config-trunk` as illustrated below:

```
#configure terminal
(config)#rsvp-trunk mytrunk ipv4
(config-trunk)#
```

rsvp-trunk force-reoptimize

Use this command to force re-optimize a particular primary LSP. Re-optimization of the LSP must have been enabled with the [reoptimize](#) command.

Command Syntax

```
rsvp-trunk TRUNKNAME force-reoptimize
```

Parameters

TRUNKNAME	Name of the trunk
-----------	-------------------

Default

NA.

Command Mode

Execute mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#rsvp-trunk t1 force-reoptimize
```

rsvp-trunk force-switchover-secondary

Use this command to force switchover a secondary LSP. This command is recommended for limited use on a stable system when there is a need for software upgrade without traffic impact.

Note: This command is supported on secondary configured tunnels and not on multiple secondary configured tunnels.

Command Syntax

```
rsvp-trunk TRUNKNAME force-switchover-secondary (off|on)
```

Parameters

TRUNKNAME	Name of the trunk
force-switchover-secondary (off on)	Force switchover to secondary

Default

NA.

Command Mode

Execute mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#rsvp-trunk <Trunk-Name> force-switchover-secondary off
```


rsvp-trunk-restart

Use this command to restart the RSVP trunk. This command “kills” an existing LSP and restarts the LSP setup process.

Command Syntax

```
rsvp-trunk-restart
```

Parameters

None

Default

By default, rsvp trunk restart is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#rsvp-trunk-restart
```

secondary ADMIN-GROUP-NAME

Use this command to configure secondary administrative groups. Administrative groups are manually assigned attributes that describe the color of links, so that links with the same color are in one class. These groups are used to implement different policy-based LSP setups. Administrative group attributes can be included or excluded for an LSP or for a path's primary and secondary paths.

Note: A link can be added to a specific Administrative Group via NSM. Refer to the *Network Services Module Command Reference* for details.

Use the `no` parameter to remove a previously set group from an administrative group list.

Command Syntax

```
secondary (include-any|include-all|exclude-any) ADMIN-GROUP-NAME
secondary (include-any|exclude-any) ADMIN-GROUP-NAME
no secondary (include-any|include-all|exclude-any) ADMIN-GROUP-NAME
no secondary (include-any|exclude-any) ADMIN-GROUP-NAME
```

Parameters

<code>include-any</code>	Include any attribute
<code>include-all</code>	Include all attribute
<code>exclude-any</code>	Exclude any attribute
<code>ADMIN-GROUP-NAME</code>	Administrative group name

Default

By default, secondary admin group name is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary exclude-any myadmingroup

#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary include-any myadmingroup

#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary include-all myadmingroup
```

secondary bandwidth

Use this command to reserve the bandwidth in bits per second for the current trunk.

Each LSP has an associated bandwidth attribute. The bandwidth value is included in the sender's RSVP Path message and specifies the bandwidth to be reserved for the LSP. It is set in bits per second, with a higher value indicating a greater user traffic volume. A zero bandwidth reserves no resources, although label exchanges are possible.

Use the `no` parameter with this command to unset the configured bandwidth information.

Command Syntax

```
secondary bandwidth BANDWIDTH
no secondary bandwidth BANDWIDTH
no secondary bandwidth
```

Parameter

BANDWIDTH	<1-999>k for 1 to 999 kilobits/s
	<1-999>m for 1 to 999 megabits/s
	<1-100>g for 1 to 100 gigabits/s

Default

By default, bandwidth is 0 bits per second, which allows data to flow through but does not reserve bandwidth.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary bandwidth 100m
```

secondary cspf

Use this command to enable the use of Constrained Shortest Path First (CSPF) server for an explicit route to the egress, or all RSVP sessions.

The CSPF server computes paths for LSPs that are subject to constraints such as bandwidth, hop count, administrative groups, priority, and explicit routes. When computing paths for LSPs, CSPF considers not only the topology of the network and the attributes defined for the LSP, but also the links. It attempts to minimize congestion by intelligently balancing the network load.

Use the `no secondary cspf` command to revert to the default settings.

Note: CSPF server information is not signaled across session and hence sessions in transit and egress nodes will not be aware of the CSPF server. So, in multi CSPF scenarios, neighbor down event from a CSPF server restart all sessions irrespective of which CSPF server sessions were using.

Command Syntax

```
secondary cspf
```

Parameters

None

Default

By default, secondary cspf is enabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows using the `no cspf` command in Trunk mode to disable CSPF for the primary LSP.

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary cspf
```

secondary cspf-retry-limit

Use this command to specify the number of retries that CSPF should carry out for a request received from RSVP.

Use the `no` parameter with this command to remove this configuration.

Command Syntax

```
secondary cspf-retry-limit <1-65535>
no secondary cspf-retry-limit
```

Parameter

<1-65535> The number of times CSPF should retry for this LSP

Default

By default, no retry limit for CSPF route calculations is configured, so the value is 0.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary cspf-retry-limit 535
```

secondary cspf-retry-timer

Use this command to specify the time between each retry that CSPF might carry out for a request received from RSVP. Use the `no` parameter with this command to remove this configuration.

Command Syntax

```
secondary cspf-retry-timer <1-600>
no secondary cspf-retry-timer
```

Parameters

<1-600> Timeout between successive retries, in seconds

Default

By default, no retry-timer configuration is defined for CSPF calculations, so the value is set to 0.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary cspf-retry-timer 45
```

secondary filter

Use this command to set the filter to fixed or shared filter style for RSVP trunk.

- The shared filter style identifies a shared reservation environment. It creates a single reservation into which flows from all senders are mixed.
- The fixed filter style designates a distinct reservation. A distinct reservation request is created for data packets from a particular sender. The fixed filter style is also used style to prevent rerouting of an LSP and to prevent another LSP from using this bandwidth.

Use the `no` parameter to reset the configured filter to the default style.

Command Syntax

```
secondary filter fixed
no secondary filter
```

Parameters

<code>fixed</code>	Use a Fixed Filter for this RSVP Trunk.
--------------------	---

Default

By default, secondary filter is shared-explicit.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Usage

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary filter fixed
```

secondary hold-priority

Use this command to configure the hold priority value for the selected trunk.

In case of insufficient bandwidth, the user must remove any less important existing LSP to free up the bandwidth. This can be done by preempting one or more of the signaled LSPs. Hold priority determines the degree to which an LSP holds onto its reservation for a session after the LSP has been configured successfully. When the hold priority is high, the existing LSP is less likely to give up its reservation.

Use the `no` parameter to revert to the default hold-priority value.

Command Syntax

```
secondary hold-priority <0-7>
no secondary hold-priority
```

Parameter

<0-7>	Specify a value for hold priority
-------	-----------------------------------

Default

The default hold-priority is 0, the highest value. Once a session is configured with a 0 hold priority value, no other session can preempt it.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary hold-priority 2
```


secondary hop-limit

Use this command to specify a limit of hops for an RSVP trunk.

Upon configuration of an arbitrary hop-limit, the hop-limit is compared with the number of hops configured in the primary path, if a primary path has been configured. If the number of hops in the primary path exceed the hop-limit configured, no path messages are sent out and any existing session is torn down. If no primary path is configured, the trunk is processed normally and the path messages are sent out. The hop-limit data is sent to the CSPF server, if CSPF is being used.

Use the `no` parameter to revert to the default hop-limit value.

Command Syntax

```
secondary hop-limit <1-255>
no secondary hop-limit <1-255>
no secondary hop-limit
```

Parameter

<1-255>	The number of acceptable hops
---------	-------------------------------

Default

By default, secondary hop limit is 255

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary hop-limit 23
```

secondary label-record

Use this command to record all labels exchanged between RSVP enabled routers during the reservation setup process. This command records all labels exchanged for an LSP from the ingress to the egress, and helps with debugging.

Use the `no` parameter to turn off recording.

Command Syntax

```
secondary label-record
no secondary label-record
```

Default

By default, secondary label record is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary label-record
```

secondary local-protection

Use this command to enable the local repair of explicit routes for which this router is a transit node.

Use the `no` parameter with this command to disable local repair of explicit routes.

Command Syntax

```
secondary local-protection
no secondary local-protection
```

Parameters

None

Default

By default, secondary local protection is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary local-protection
```

no secondary affinity

Use this command to disable the use of sending out session attribute objects with resource affinity data.

Use the [secondary bandwidth](#) command to revert to the default settings.

Command Syntax

```
no secondary affinity
```

Parameters

None

Default

By default, no secondary affinity is disabled.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no secondary affinity
```

no secondary cspf

Use this command to disable the use of Constrained Shortest Path First (CSPF) server for an explicit route to the egress, or all RSVP sessions.

If CSPF is turned off globally, it cannot be enabled for any LSP. If used per LSP, it can be used to turn off CSPF computation for a specific LSP. The CSPF server computes paths for LSPs that are subject to various constraints such as bandwidth, hop count, administrative groups, priority, and explicit routes. When computing paths for LSPs, CSPF considers not only the topology of the network and the attributes defined for the LSP, but, also the links. It attempts to minimize congestion by intelligently balancing the network load.

Disable CSPF when all nodes do not support the required traffic engineering extensions and configure LSPs manually to use an explicit path. The LSP is then established only along the path specified by the operator.

Use the [secondary cspf](#) command to revert to the default settings.

Command Syntax

```
no secondary cspf
```

Parameters

None

Default

By default, secondary no cspf is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows using the `no cspf` command in Trunk mode to disable CSPF for the primary LSP.

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no secondary cspf
```

no secondary record

This command is used to disable recording of the route taken by path and resv messages and confirms the establishment of reservations and to identify errors. Routes are recorded by means of the route record object (RRO) in an RSVP message.

Use the [secondary record](#) command to revert to the default settings.

Command Syntax

```
no secondary record
```

Parameters

None

Default

By default, routes are recorded

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no secondary record
```

secondary path

Use this command to specify an RSVP path to be used.

Use the `no` parameter with this command to remove a configured RSVP path.

Command Syntax

```
secondary path PATHNAME
no secondary path
```

Parameters

PATHNAME	The name of the path to be used. <code>PATHNAME</code> is a string (name) used to identify an RSVP path defined for the node (refer to the rsvp-path command).
----------	--

Default

By default, secondary path is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary path mypath
```

secondary-priority path

Use this command to specify a RSVP path to be used for a specific priority secondary.

Use the no parameter with this command to remove a configured secondary-priority.

Command Syntax

```
secondary-priority <1-5> path PATHNAME
no secondary-priority <1-5>
```

Parameters

<1-5>	Secondary Priority value.
PATHNAME	The name of the path to be used. <code>PATHNAME</code> is a string (name) used to identify an RSVP path defined for the node (refer to the rsvp-path command).

Default

Secondary-priority can only be configured along with a path. Other attributes can only be associated post this command.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk t1
(config-trunk)#secondary-priority 1 path spl
(config)# rsvp-trunk t1
(config-trunk)#no secondary-priority 1
```


secondary-priority hold-priority

Use this command to configure the hold priority value for the secondary-priority lsp.

In case of insufficient bandwidth, the user must remove any less important existing LSP to free up the bandwidth. This can be done by preempting one or more of the signaled LSPs. Hold priority determines the degree to which an LSP holds onto its reservation for a session after the LSP has been configured successfully. When the hold priority is high, the existing LSP is less likely to give up its reservation.

Use the no parameter to revert to the default hold-priority value.

Command Syntax

```
secondary-priority <1-5> hold-priority <0-7>
no secondary-priority <1-5> hold-priority <0-7>
no secondary-priority <1-5> hold-priority
```

Parameters

<1-5>	Secondary Priority value.
<0-7>	Specify a value for hold priority.

Default

The default hold-priority is 0, the highest value. Once a session is configured with a 0 hold priority value, no other session can preempt it.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
(config)# rsvp-trunk t1
(config-trunk)#secondary-priority 1 hold-priority 4
(config)# rsvp-trunk t1
(config-trunk)# no secondary-priority 1 hold-priority
```

secondary-priority setup-priority

Use this command to configure a setup priority value for the secondary-priority lsp.

In case of insufficient bandwidth, the user must remove any less important LSPs to free up bandwidth. This can be done by preempting one or more of the existing LSPs. The setup priority determines whether a new LSP that preempts an existing LSP may be established. The setup priority of the new LSP must be higher than the hold priority of an existing LSP for the existing LSP to be preempted. Note that for a trunk, the setup priority should not be higher than the hold priority.

Use the no parameter with this command to revert to the default setup priority value.

Command Syntax

```
secondary-priority <1-5> setup-priority <0-7>
no secondary-priority <1-5> setup-priority <0-7>
```

Parameters

<1-5>	Secondary Priority value.
<0-7>	Specify a value for hold priority.

Default

By default, setup value is 7 (the lowest).

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
(config)# rsvp-trunk t1
(config-trunk)#secondary-priority 1 setup-priority 4
(config)# rsvp-trunk t1
(config-trunk)# no secondary-priority 1 setup-priority 4
```

secondary-priority label-record

Use this command to record all labels exchanged between RSVP enabled routers during the reservation setup process. This command records all labels exchanged for an LSP from the ingress to the egress, and helps with debugging.

Use the no parameter to turn off recording.

Command Syntax

```
secondary-priority <1-5> label-record  
no secondary-priority <1-5> label-record
```

Parameters

<1-5> Secondary Priority value.

Default

By default, label record is disabled for secondary-priority.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
(config)# rsvp-trunk t1  
(config-trunk)#secondary-priority 1 label-record  
(config)# rsvp-trunk t1  
(config-trunk)# no secondary-priority 1 label-record
```

secondary-priority hop-limit

Use this command to specify a limit of hops for a secondary-priority lsp.

Upon configuration of an arbitrary hop-limit, the hop-limit is compared with the number of hops configured in the path, if a path has been configured. If the number of hops in the path exceed the hop-limit configured, no path messages are sent out and any existing session is torn down.

Use the no parameter to revert to the default hop-limit value.

Command Syntax

```
secondary-priority <1-5> hop-limit <1-255>
no secondary-priority <1-5> hop-limit <1-255>
```

Parameters

<1-5>	Secondary Priority value.
<1-255>	The number of acceptable hops.

Default

By default, hop limit is 255.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
(config)# rsvp-trunk t1
(config-trunk)#secondary-priority 1 hop-limit 123
(config)# rsvp-trunk t1
(config-trunk)# no secondary-priority 1 hop-limit 123
```

secondary-priority bandwidth

Use this command to reserve the bandwidth in bits per second for the current trunk.

Each LSP has an associated bandwidth attribute. The bandwidth value is included in the sender's RSVP Path message and specifies the bandwidth to be reserved for the LSP. It is set in bits per second, with a higher value indicating a greater user traffic volume. A zero bandwidth reserves no resources, although label exchanges are possible.

Use the no parameter with this command to unset the configured bandwidth information.

Command Syntax

```
secondary-priority <1-5> bandwidth BANDWIDTH
no secondary-priority <1-5> bandwidth BANDWIDTH
```

Parameters

<1-5>	Secondary Priority value.
BANDWIDTH	<1-999>k for 1 to 999 kilobits/s <1-999>m for 1 to 999 megabits/s <1-100>g for 1 to 100 gigabits/s

Default

By default, bandwidth is 0 bits per second, which allows data to flow through but does not reserve bandwidth.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
(config)# rsvp-trunk t1
(config-trunk)#secondary-priority 1 bandwidth 100m
(config)# rsvp-trunk t1
(config-trunk)# no secondary-priority 1 bandwidth 100m
```

secondary record

This command is used to enable recording of the route taken by path and resv messages to confirm the establishment of reservations and to identify errors. Routes are recorded by means of the route record object (RRO) in RSVP messages.

Use the [no secondary record](#) command to revert to the default settings.

Command Syntax

```
secondary record
```

Parameters

None

Default

By default, routes are recorded

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary record
```

secondary retry-limit

Use this command to specify a retry count this RSVP Trunk.

If a session is in a nonexistent state due to the receipt of a path error message, it tries to recreate the LSP for the number of times specified by [primary retry-limit](#). Although the same retry command controls both the trunk and the session, the retry-limit value affects only the session and not the trunk. If the trunk is in an incomplete state, the code keeps trying to bring it to a complete state, irrespective of the retry-limit value.

Use the `no` parameter to revert to the default retry-limit value.

Command Syntax

```
secondary retry-limit <1-65535>
no secondary retry-limit
```

Parameter

<1-65535>	The set number of times the system should try setting up the LSP
-----------	--

Default

By default, the retry-limit value is 0 so the trunk and session try to create the LSP indefinitely.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary retry-limit 256
```

secondary retry-timer

Use this command to specify a retry interval for an RSVP Trunk. When the ingress tries to configure an LSP and the setup fails due to the receipt of a path error message, the system waits for the time configure by this command before retrying the LSP setup process.

Use the `no` parameter to revert to the default.

Command Syntax

```
secondary retry-timer <1-600>
no secondary retry-timer
```

Parameter

<code><1-600></code>	Interval after which the system should retry setting up the LSP, in seconds
----------------------------	---

Default

By default, retry time is 30 seconds

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary retry-timer 12
```


secondary reuse-route-record

Use this command to use the updated route record list as an explicit route (with all strict nodes) when a path message is sent out at the next refresh.

An explicit route object (ERO) list contains the hops to be taken to reach the egress from the current LSR. If CSPF can not place an ERO with all strict routes, then this command helps modify the ERO after receiving resv messages. Future path messages have the ERO with all strict nodes, which identify each and every node to be traversed.

Use the `no` parameter to disable the use of the route record list as the explicit route.

Command Syntax

```
secondary reuse-route-record
no secondary reuse-route-record
```

Parameters

None

Default

By default, secondary reuse route record is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary reuse-route-record
```

secondary setup-priority

Use this command to configure a setup priority value for this trunk.

In case of insufficient bandwidth, the user must remove any less important LSPs to free up bandwidth. This can be done by preempting one or more of the existing LSPs. The setup priority determines whether a new LSP that preempts an existing LSP may be established. The setup priority of the new LSP must be higher than the hold priority of an existing LSP for the existing LSP to be preempted. Note that for a trunk, the setup priority should not be higher than the hold priority.

Use the `no` parameter with this command to revert to the default setup priority value.

Command Syntax

```
secondary setup-priority <0-7>  
no secondary setup-priority
```

Parameters

<0-7>	The priority value
-------	--------------------

Default

By default, setup value is 7 (the lowest).

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal  
(config)#rsvp-trunk mytrunk  
(config-trunk)#secondary setup-priority 2
```

secondary traffic

Use this command to identify the traffic type for this RSVP Trunk.

Use the `no` parameter with this command to unset the configured traffic type.

Command Syntax

```
secondary traffic (guaranteed|controlled-load)
no secondary traffic
```

Parameters

<code>guaranteed</code>	Guaranteed traffic
<code>controlled-load</code>	Controlled load traffic

Default

Controlled load is the default traffic type.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary traffic guaranteed
```

shutdown

Use this command to administratively disable a trunk. Execute this command to release the sessions of this trunk, and it only comes up once it is administratively enabled.

Use the `no` parameter to enable the trunk.

Command Syntax

```
shutdown
no shutdown
```

Parameters

None

Default

None

Command Mode

Trunk mode

Applicability

Introduced in OcNOS version 6.5.1.

Examples

The below example disable the trunk administratively:

```
#configure terminal
(config)#rsvp-trunk t1
(config-trunk)#shutdown
(config-trunk)#commit
```

The below example enable the trunk administratively:

```
#configure terminal
(config)#rsvp-trunk t1
(config-trunk)#no shutdown
(config-trunk)#commit
```

snmp restart rsvp

Use this command to restart SNMP in Resource Reservation Protocol -Traffic Engineering (RSVP-TE)

Command Syntax

```
snmp restart rsvp
```

Parameters

None

Default

By default, snmp restart rsvp is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#snmp restart rsvp
```

to A.B.C.D

Use this command to specify an IPv4 egress for an LSP. When configuring an LSP, you must specify the address of the egress router by using this command in the trunk node. An egress definition is a mandatory attribute; no RSVP session is created when an egress is not defined.

Use the `no` parameter with this command to unset the configured egress address.

Command Syntax

```
to A.B.C.D
no to
```

Parameters

None

Default

The operator must specify an egress for LSP initialization to begin.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#to 10.10.0.5
```

update-type

Use this command to change the method of updating attributes for sessions (primary/ secondary) for this trunk.

- If make-before-break is configured (default type), a new LSP is created for each attribute update. When the new LSP becomes operational, the original LSP is torn down.
- If break-before-make is configured, the existing LSP is torn down and restarted for each attribute update.

Use the `no` parameter with this command to remove an update type.

Command Syntax

```
update-type (make-before-break|break-before-make)
no update-type
```

Parameters

```
make-before-break
                        Make before break update
break-before-make
                        Break before make update
```

Default

By default, make-before-break types of updates are carried out.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#update-type break-before-make

#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#update-type make-before-break
```

CHAPTER 2 Fast Reroute Commands

This chapter describes the RSVP-TE Fast Reroute commands.

Note: Constrained Shortest Path First (CSPF) is mandatory for FRR to work.

- [detour-allow-primary-upstream-path](#)
- [default-frr-protection](#)
- [detour-identification](#)
- [primary fast-reroute bandwidth](#)
- [primary fast-reroute hold-priority](#)
- [primary fast-reroute hop-limit](#)
- [primary fast-reroute node-protection](#)
- [primary fast-reroute protection](#)
- [primary fast-reroute setup-priority](#)

default-frr-protection

Use this command to configure the default method of fast reroute protection when sender has not specified a method via FRR object but asked for local protection. This command is particularly useful with interop with Cisco as Cisco doesn't send FRR object in path message. By default, default FRR protection considered to be one-to-one in OcNOS and in case of interop with Cisco where default protection needed is facility, this command shall be configured on all OcNOS devices in the network.

Note: Having this command configured in one OcNOS device and not configured in other OcNOS device in the network will cause unpredictable behavior as RFC recommendation for merge node behavior of facility and one-to-one are different.

Note: This command is applicable only when path message contains local protection flag set but doesn't contain FRR object. When FRR object mentions protection type explicitly, this command is not applicable and also, if path message doesn't request local protection, then also this command is not applicable.

Command Syntax

```
default-frr-protection (one-to-one | facility)
no default-frr-protection
```

Parameters

facility	Facility Backup (Bypass) protection
one-to-one	One-to-One protection mechanism

Default

By default, if local protection requested but FRR object not available, one-to-one protection is considered.

Command Mode

Router mode

Applicability

This command was introduced in OcNOS version 6.3.1.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)# default-frr-protection facility
(config-router)# commit
(config-router)# no default-frr-protection
(config-router)# commit
```

detour-identification

Use this command to set a path-specific detour LSP identification method, using the detour object.

Use the no parameter with this command to unset the detour LSP identification method.

Note: This command helps identify the backup LSP identification method for one-to-one protection only.

Command Syntax

```
detour-identification (path|sender-template)
no detour-identification
```

Parameters

path	Set a path-specific detour identification method
sender-template	Set a sender template-specific detour identification method

Default

By default, detour identification is sender template

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#detour-identification path

#configure terminal
(config)#router rsvp
(config-router)#detour-identification sender-template

#configure terminal
(config)#router rsvp
(config-router)#no detour-identification
```

primary fast-reroute bandwidth

Use this command to set the detour LSP bandwidth.

Note: This command helps identify attributes of the FRR backup LSP for the one-to-one protection method.

Use the `no` parameter with this command to unset fast-reroute LSP bandwidth.

Command Syntax

```
primary fast-reroute bandwidth BANDWIDTH
no primary fast-reroute bandwidth BANDWIDTH
no primary fast-reroute BANDWIDTH
```

Parameter

BANDWIDTH	<1-999>k for 1 to 999 kilobits/s
	<1-999>m for 1 to 999 megabits/s
	<1-100>g for 1 to 100 gigabits/s

Default

By default, primary fast reroute bandwidth is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary fast-reroute bandwidth 10000000
```

primary fast-reroute hold-priority

Use this command to set the hold-priority for a detour LSP.

Note: This command helps identify attributes of the FRR backup LSP for the one-to-one protection method.

Use the `no` parameter with this command to unset the detour LSP hold-priority.

Command Syntax

```
primary fast-reroute hold-priority <0-7>
no primary fast-reroute hold-priority (<0-7>|)
```

Parameter

<0-7>	Set the value for hold-priority
-------	---------------------------------

Default

By default, primary fast reroute hold priority is 0

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary fast-reroute hold-priority 3
```

primary fast-reroute hop-limit

Use this command to set the hop-limit for a detour LSP.

Note: This command helps identify attributes of the FRR backup LSP for the one-to-one protection method.

Use the `no` parameter with this command to unset the detour LSP hop-limit.

Command Syntax

```
primary fast-reroute hop-limit <1-255>
no primary fast-reroute hop-limit (<1-255>|)
```

Parameter

<1-255>	Set the number of hops
---------	------------------------

Default

By default, primary fast reroute hop limit is 255

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary fast-reroute hop-limit 25
```

primary fast-reroute node-protection

Use this command to set node protection.

Note: This command helps identify attributes of the FRR backup LSP for the one-to-one protection method.

Use the `no` parameter with this command to remove node protection.

Command Syntax

```
primary fast-reroute node-protection
no primary fast-reroute node-protection
```

Parameters

None

Default

By default, primary fast reroute node protection is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary fast-reroute node-protection
```

primary fast-reroute protection

Use this command to create an Fast Reroute backup and to set an LSP one-to-one protection or facility backup mechanism.

Note: Traffic switching of less than 50ms is not applicable for unknown unicast traffic received on edge nodes for VPLS services.

Use the `no` parameter with this command to remove LSP protection mechanism.

Parameters

None

Command Syntax

```
primary fast-reroute protection (one-to-one|facility)
no primary fast-reroute protection (one-to-one|facility)
```

Parameters

<code>one-to-one</code>	One-to-one protection
<code>facility</code>	Facility backup (bypass) protection"

Default

By default, primary fast reroute protection is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary fast-reroute protection one-to-one
```

primary fast-reroute setup-priority

Use this command to configure a setup-priority for the detour LSP.

Note: This command helps identify attributes of the FRR backup LSP for the one-to-one protection method.

Use the `no` parameter with this command to remove the detour LSP setup-priority.

Command Syntax

```
primary fast-reroute setup-priority <0-7>
no primary fast-reroute setup-priority (<0-7>|)
```

Parameter

<0-7>	Set a value for setup priority
-------	--------------------------------

Default

By default, primary fast reroute setup priority is 0

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary fast-reroute setup-priority 2
```


CHAPTER 3 Refresh Reduction Commands

This chapter describes the RSVP-TE Refresh Reduction commands:

- [ack-send-timer](#)
- [ack-wait-timeout](#)
- [message-ack](#)
- [refresh-reduction](#)
- [rsvp ack-wait-timeout](#)
- [rsvp message-ack](#)
- [rsvp refresh-reduction](#)

ack-send-timer

Use this command to configure the timer to send an acknowledgement message. Timer configuration increases the chances of piggy backing multiple acknowledgement messages but also adds delay in acknowledgment received by neighbor node. So, use this command with exact knowledge of optimum time.

Note: Configure this command with a value within the limit of ack-wait-timeout to avoid frequent timeout.

Command Syntax

```
ack-send-timer <1-5>
no ack-send-timer
```

Parameter

<1-5> Value in seconds for acknowledgement send timer.

Default

By default, acknowledgement message is transmitted immediately without piggy-backing.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 6.4.1.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)# ack-send-timer 1
(config-router)# commit
(config-router)# no ack-send-timer
(config-router)# commit
```

ack-wait-timeout

Use this command to configure the acknowledgement wait timeout for all RSVP-TE neighbors.

Use the `no` parameter with this command to revert to the default acknowledgement wait timeout.

Command Syntax

```
ack-wait-timeout <1-65535>
no ack-wait-timeout
```

Parameter

<code><1-65535></code>	Specify a value for the acknowledgement wait timeout in seconds. The default timeout value is 10 seconds.
------------------------------	---

Default

By default, ack wait timeout is 10 seconds

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#ack-wait-timeout 5

(config)#router rsvp
(config-router)#no ack-wait-timeout
```

message-ack

Use this command to enable message acknowledgment for all messages being sent to neighbors that are known to support refresh reduction.

Use the `no` parameter with this command to disable message acknowledgment for all messages being sent to neighbors.

Command Syntax

```
message-ack
no message-ack
```

Parameters

None

Default

By default, Message Acknowledgment is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#message-ack

(config)#router rsvp
(config-router)#no message-ack
```

refresh-reduction

Use this command to enable refresh reduction capability advertisement for all interfaces.

Use the `no` parameter with this command to disable refresh reduction capability advertisement for all interfaces.

Command Syntax

```
refresh-reduction
no refresh-reduction
```

Parameters

None

Default

By default, Refresh reduction mechanism is enabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#refresh-reduction

(config)#router rsvp
(config-router)#no refresh-reduction
```

rsvp ack-wait-timeout

Use this command to configure the acknowledgment wait timeout for all neighbors detected via the specific interface.

Use the `no` parameter with this command to revert to the default acknowledgment wait timeout for the specified interface.

Command Syntax

```
rsvp ack-wait-timeout <1-65535>
no rsvp ack-wait-timeout
```

Parameters

<1-65535>	Specify a value for the acknowledgment wait timeout in seconds. The default timeout value is 10 seconds.
-----------	--

Default

By default, rsvp ack wait timeout is 10 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp ack-wait-timeout 5

(config)#interface eth0
(config-if)#no rsvp ack-wait-timeout
```

rsvp message-ack

Use this command to enable message acknowledgment for all messages being sent to the neighbors that have been detected via the specific interface.

Use the `no` parameter with this command to disable message acknowledgment for all messages being sent to the neighbors that have been detected via the specified interface.

Command Syntax

```
rsvp message-ack
no rsvp message-ack
```

Parameters

None

Default

By default, Message Acknowledgment is disabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp message-ack

(config)#interface eth0
(config-if)#no rsvp message-ack
```

rsvp refresh-reduction

Use this command to enable Refresh Reduction capability advertisement for a specific interface.

Use the `no` parameter with this command to disable Refresh Reduction capability advertisement for the specified interface.

Command Syntax

```
rsvp refresh-reduction
no rsvp refresh-reduction
```

Parameters

None

Default

Refresh Reduction mechanism is enabled by default for all interfaces.

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp refresh-reduction

(config)#interface eth0
(config-if)#no rsvp refresh-reduction
```

CHAPTER 4 Facility Backup Commands

This chapter describes the RSVP-TE bypass commands for facility backup protection

- [RSVP Auto Bypass Commands](#)
- [backup-bw-type](#)
- [bandwidth](#)
- [bypass-lsp-addr-query-interval](#)
- [cspf-retry-limit](#)
- [cspf-retry-timer](#)
- [filter](#)
- [hold-priority](#)
- [hop-limit](#)
- [label-record](#)
- [no record](#)
- [path](#)
- [preemption-type](#)
- [record](#)
- [retry-limit](#)
- [retry-timer](#)
- [reuse-route-record](#)
- [rsvp-bypass](#)
- [setup-priority](#)
- [shutdown](#)
- [to A.B.C.D](#)
- [traffic](#)

backup-bw-type

Use this command to select the bypass trunk bandwidth support type.

Bypass trunks of dedicated bandwidth type will serve only bandwidth protections requested LSPs. The total bandwidth requirement of served LSPs will be less than or equal to the bandwidth configured on the bypass trunk. If an LSP with bandwidth protection and higher setup priority requests protection and bypass doesn't have sufficient bandwidth available, then LSPs with lower hold priority will be preempted to serve the LSP with higher setup priority.

Use the `no` parameter to remove configured backup bandwidth type.

Command Syntax

```
backup-bw-type (dedicated | best-effort)
no backup-bw-type
```

Parameters

<code>dedicated</code>	Dedicated backup bandwidth support
<code>best-effort</code>	Best effort backup bandwidth support

Default

`best-effort`

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#backup-bw-type dedicated
```

bandwidth

Use this command to reserve the bypass bandwidth in bits per second for the current trunk.

Each LSP has an associated bandwidth attribute. The bandwidth value is included in the sender's RSVP Path message and specifies the bandwidth to be reserved for the LSP. It is specified in bits per second, with a higher value indicating a greater user traffic volume. A zero bandwidth reserves no resources, although exchanges labels.

Use the `no` parameter to remove configured bandwidth information.

Command Syntax

```
bandwidth BANDWIDTH
no bandwidth BANDWIDTH
no bandwidth
```

Parameter

BANDWIDTH	<1-999>k for 1 to 999 kilobits/s
	<1-999>m for 1 to 999 megabits/s
	<1-100>g for 1 to 100 gigabits/s

Default

The default bandwidth is 0 bits per second, which allows data to flow through but does not reserve bandwidth.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#bandwidth 100m
(config-bypass)#no bandwidth
```

bypass-lsp-addr-query-interval

Use this command to set the interval at which bypass trunk must query CSPF for LSP address. This mechanism ensures to update bypass trunk LSP addresses regularly so that, it can verify regularly if it can protect any LSP requesting protection.

Use the `no` parameter with this command to reset the interval to default value.

Note: Reducing interval to lower values may impact performance.

Command Syntax

```
bypass-lsp-addr-query-interval <10-60>  
no bypass-lsp-addr-query-interval
```

Parameter

<10-60>	Set interval of bypass trunk querying LSP address
---------	---

Default

By default, interval is set to 60 seconds.

Command Mode

Router mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal  
(config)#router rsvp  
(config-router)# bypass-lsp-addr-query-interval 50
```

cspf-retry-limit

Use this command to specify the number of retries that CSPF should carry out for a request received from RSVP.

Use the `no` parameter with this command to disable this configuration.

Command Syntax

```
cspf-retry-limit <1-65535>
no cspf-retry-limit
```

Parameter

`<1-65535>` Set the number of times CSPF should retry for this LSP

Default

By default, retry-limit is 0 which means infinite retry.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#cspf-retry-limit 535

(config)#rsvp-bypass bp1
(config-bypass)#no cspf-retry-limit
```

cspf-retry-timer

Use this command to specify the time between each retry that CSPF might carry out for a request received from RSVP. Use the no parameter with this command to disable this configuration.

Command Syntax

```
primary cspf-retry-timer <1-600>
no primary cspf-retry-timer
```

Parameter

<1-600>	Timeout between successive retries, in seconds
---------	--

Default

By default, retry-timer is 0

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#cspf-retry-timer 45

(config)#rsvp-bypass bp1
(config-bypass)#no cspf-retry-timer
```

filter

Use this command to set the filter to the fixed or shared style for an LSP.

- The shared filter style identifies a shared reservation environment. It creates a single reservation into which flows from all senders are mixed.
- The fixed filter style designates a distinct reservation. A distinct reservation request is created for data packets from a particular sender. The fixed filter style is also used style to prevent rerouting of an LSP and to prevent another LSP from using this bandwidth.

Use the `no` parameter to reset the configured filter to the default.

Command Syntax

```
filter fixed
no filter
```

Parameters

<code>fixed</code>	Use a fixed filter for this LSP
--------------------	---------------------------------

Default

By default, bypass filter is shared-explicit.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#filter fixed
```

hold-priority

Use this command to configure the hold priority value for the selected bypass trunk. In case of insufficient bandwidth, remove less important existing LSPs to free up a portion of the bandwidth. This can be done by preempting one or more of the signaled LSPs. Hold priority determines the degree to which an LSP holds onto its reservation for a session after the LSP has been configured successfully. When the hold priority is high, the existing LSP is less likely to give up its reservation.

Use the `no` parameter to reset the trunk to the default hold-priority value.

Command Syntax

```
hold-priority <0-7>
no hold-priority
```

Parameters

<code><0-7></code>	Set a hold priority for the bypass LSP
--------------------------	--

Default

The default hold-priority value is 0, which is the highest. Once a session is configured with a hold priority of 0, no other session can preempt it.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#hold-priority 2
```

hop-limit

Use this command to specify a limit of hops for an RSVP bypass trunk. Hop-limit data is sent to the CSPF server if CSPF is used.

Upon configuration of an arbitrary hop-limit, the hop-limit is compared with the number of hops configured in the bypass path, if a bypass path has been configured. If the number of hops in the bypass path exceeds the hop-limit configured, no Path messages are sent, and any existing session is torn down. If no bypass path is configured, the bypass trunk is processed normally and Path messages are sent.

Use the `no` parameter to reset the bypass trunk to the default hop-limit value.

Command Syntax

```
hop-limit <1-255>
no hop-limit
```

Parameters

<1-255>	Set the number of acceptable hops for the LSP
---------	---

Default

By default, bypass hop limit is 255

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#hop-limit 23
```

label-record

Use this command to record all labels exchanged between RSVP-enabled routers during the reservation setup process.

Use the `no` parameter with this command to turn off recording.

Command Syntax

```
label-record
no label-record
```

Parameters

None

Default

By default, bypass label record is disabled

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#label-record
```

no record

Use this command to disable recording of the route taken by Path and Reservation Request (Resv) messages to confirm establishment of reservations and identify errors. Routes are recorded by means of the Route Record Object (RRO) in RSVP messages.

Use the `record` command to return to the default settings.

Command Syntax

```
no record
```

Parameters

None

Default

By default, routes are recorded

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bpl
(config-bypass)#no record
```

path

Use this command to specify an RSVP path to be used. The PATHNAME in this command is the string (name) used to identify an RSVP path defined for the node (refer to rsvp-path command).

Use the `no` parameter with this command to remove a configured RSVP path.

Command Syntax

```
path PATHNAME
no path
```

Parameters

PATHNAME	The name of the path to use
----------	-----------------------------

Default

By default, bypass path is disabled

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#path mypath
```

preemption-type

Use this command to configure preemption type which decides the criteria to be considered in case of preemption.

Use the `no` parameter to remove configured preemption type.

Command Syntax

```
preemption-type (less-lsp-preempted | less-unused-bandwidth)
no preemption-type
```

Parameters

<code>less-lsp-preempted</code>	Set preemption type to minimize number of LSPs preempted
<code>less-unused-bandwidth</code>	Set preemption type to ensure less bypass bandwidth unused

Default

By default, preemption type is set to `less-lsp-preempted`.

Command Mode

Router mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#preemption-type less-unused-bandwidth
```

record

Use this command to enable recording of the route taken by Path and Reservation Request (Resv) messages to confirm establishment of reservations and identify errors. Routes are recorded by means of the Route Record Object (RRO) in RSVP messages.

Use the `no record` command to disable recording of routes.

Command Syntax

```
record
```

Parameters

None

Default

By default, routes are recorded

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bpl
(config-bypass)#record
```

retry-limit

Use this command to specify a retry count this RSVP bypass Trunk.

If a session is in a nonexistent state due to a path error message, the system tries to recreate the LSP for the number of times specified by the retry-limit command.

Although the same retry command controls both the trunk and the session, the retry-limit value affects only the session and not the trunk. If the trunk is in an incomplete state, the code keeps trying forever to bring it to a complete state regardless of the retry-limit value.

Use the `no` parameter with this command to revert to the default retry-limit value.

Command Syntax

```
retry-limit <1-65535>
no retry-limit
```

Parameter

`<1-65535>` The set number of times the system should try setting up the LSP

Default

By default, the retry-limit value is 0, and the trunk and session try to create the LSP indefinitely.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#retry-limit 256
```

retry-timer

Use this command to specify a retry interval for an RSVP bypass Trunk. When an ingress node tries to configure an LSP and the setup fails due to the receipt of a Path Error message, the system waits for the time configured with this command, before retrying the LSP setup process.

Use the `no` parameter with this command to revert to the default retry-time value.

Command Syntax

```
retry-timer <1-600>
no retry-timer
```

Parameters

<1-600>	Time in seconds after which the system should retry setting up the LSP
---------	--

Default

By default, retry-timer value is 30 seconds.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#retry-timer 12
```

reuse-route-record

Use this command to use the updated Route Record List as an Explicit Route (with all strict nodes) when a path message is sent out at the next refresh.

The ERO list contains the hops to be taken to reach the egress from the current LSR. If CSPF is not available, to place an ERO with all strict routes, use this command to modify the ERO after receiving the Resv message. The future Path messages have the ERO with all strict nodes, identifying each and every node to be traversed.

Use the `no` parameter with this command to disable the use of the Route Record List as the explicit route.

Command Syntax

```
reuse-route-record
no reuse-route-record
```

Parameters

None

Default

By default, reuse route record is disabled

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#reuse-route-record
```

rsvp-bypass

Use this command to create a new RSVP bypass trunk. When the bypass trunk is created, the attributes required to configure an explicitly-routed or traditionally-routed LSP are set. Once a trunk is configured with the required attributes, an RSVP bypass session (and PSB) is created for this trunk, which enables the exchange of messages and completes the LSP setup.

This command also modifies an existing RSVP path to configure an explicitly-routed or traditionally-routed LSP.

Use the `no` parameter with this command to remove an RSVP bypass trunk and all configured attributes.

Note: The RSVP bypass' name (BYPASSNAME) is limited to 32 characters.

Command Syntax

```
rsvp-bypass BYPASSNAME
no rsvp-bypass BYPASSNAME
```

Parameters

BYPASSNAME	Name to use for the bypass trunk
------------	----------------------------------

Default

By default, `rsvp bypass trunk` is disabled

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

The command prompt changes from `config` to `config-bypass` as illustrated below:

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#
```

setup-priority

Use this command to configure a setup priority value for a trunk. In case of insufficient bandwidth, users must remove less important LSPs to free up the bandwidth. This can be done by preempting one or more of the existing LSPs. The primary setup priority determines if a new LSP can preempt an existing LSP.

The setup priority of the new LSP must be higher than the hold priority of an existing LSP for the existing LSP to be preempted. Note that for a trunk, the setup priority should not be higher than the hold priority.

Use the `no` parameter with this command to revert to the default primary setup priority value.

Command Syntax

```
setup-priority <0-7>
no setup-priority
```

Parameters

<0-7>	Set the priority value
-------	------------------------

Default

By default, setup priority is 7, which is the lowest.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#setup-priority 2
```

shutdown

Use this command to administratively disable a bypass trunk. Execute this command to release the bypass session of this trunk, and it only comes up once it is administratively enabled.

Use the `no` parameter to enable the trunk.

Command Syntax

```
shutdown
no shutdown
```

Parameters

None

Default

None

Command Mode

Bypass mode

Applicability

Introduced in OcNOS version 6.5.1.

Examples

The below example disable the trunk administratively:

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#shutdown
(config-bypass)#commit
```

The below example enable the trunk administratively:

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#no shutdown
(config-bypass)#commit
```

to A.B.C.D

Use this command to specify an IPv4 egress for a bypass LSP. When configuring an LSP, you must specify the address of the egress router by using this command in the bypass node. An egress definition is a mandatory attribute; no RSVP session is created when an egress is not defined.

Use the `no` parameter with this command to unset the configured egress address.

Command Syntax

```
to A.B.C.D
no to
```

Parameters

None

Default

The operator must specify an egress for LSP initialization to begin.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#to 10.10.0.5
```

traffic

Use this command to specify the traffic type for this RSVP bypass Trunk.

Use the `no` parameter with this command to reset the configured traffic type.

Command Syntax

```
traffic (guaranteed|controlled-load)
no traffic
```

Parameters

<code>controlled-load</code>	Controlled loaded traffic
<code>guaranteed</code>	Guaranteed traffic

Default

By default, primary traffic type is controlled-load

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#traffic guaranteed
```

CHAPTER 5 Differentiated Services Commands

This chapter describes the RSVP Differentiated Services (DiffServ) commands.

- `map-route A.B.C.D`
- `map-route X:X::X:X`
- `override-diffserv`
- `primary class-to-exp-bit`
- `primary elsp-signaled`
- `primary llsp`
- `secondary map class`
- `secondary elsp-signaled`
- `secondary llsp`
- `show rsvp diffserv-info`

map-route A.B.C.D

Use this command to map a IPv4 prefix route onto a trunk. This route is to be used for packets that are mapped to a specific RSVP trunk.

Use the `no` parameter with this command for unmapping routes from specified trunks.

Note: Do not configure the local address as a map route, as explicit validation is not done. The wrong configuration may impact traffic.

Command Syntax

```
map-route A.B.C.D A.B.C.D
map-route A.B.C.D A.B.C.D CLASS
map-route A.B.C.D/M
map-route A.B.C.D/M CLASS
no map-route A.B.C.D A.B.C.D
no map-route A.B.C.D A.B.C.D CLASS
no map-route A.B.C.D/M
no map-route A.B.C.D/M CLASS
```

Parameters

A.B.C.D	Specify the IPV4 address to be mapped.
A.B.C.D	Specify a mask to be applied to the address being mapped.
A.B.C.D/M	Specify the IPV4 address to be mapped, with mask.
CLASS	Specify the DiffServ Class Name (for example, <code>be</code> , <code>ef</code> etc.) used for selecting incoming IP packets to be mapped to a specified RSVP trunk.

Default

By default, map route A.B.C.D is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#map-route 1.1.2.2/24 be
```


map-route X:X::X:X

Use this command to map a IPv6 prefix route onto a trunk. This route is to be used for packets that are mapped to a specific RSVP trunk.

Use the `no` parameter with this command for unmapping routes from specified trunks.

Command Syntax

```
map-route X:X::X:X X:X::X:X
map-route X:X::X:X X:X::X:X CLASS
map-route X:X::X:X/M
map-route X:X::X:X/M CLASS
no map-route X:X::X:X X:X::X:X
no map-route X:X::X:X X:X::X:X CLASS
no map-route X:X::X:X/M
no map-route X:X::X:X/M CLASS
```

Parameters

X:X::X:X	Specify the IPV6 address to be mapped.
X:X::X:X	Specify a mask to be applied to the address being mapped.
X:X::X:X/M	Specify the IPV6 address to be mapped, with mask.
CLASS	Specify the DiffServ Class Name (for example, <code>be</code> , <code>ef</code> etc.) used for selecting incoming IP packets to be mapped to a specified RSVP trunk.

Default

By default, map route X:X::X:X is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#map-route 1.1.2.2/24 be
```

override-diffserv

Use this command to enable the Differentiated Services (Diff-Serv) override configuration.

If a Path message is received without a Diff-Serv object by a Diff-Serv enabled node, it can be interpreted either as a request for an E-LSP (EXP-Inferred-PSC LSP) or as a request for Non-Diff-Serv LSP. This command supports the override option and when configured, the LSR interprets a path message without a Diff-Serv object as a request for Non-Diff-Serv LSP.

Use the `no` parameter with this command disable this feature.

Command Syntax

```
override-diffserv
no override-diffserv
```

Parameters

None

Default

By default, override diffserv is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router rsvp
(config-router)#override-diffserv
```

primary class-to-exp-bit

Use this command to configure a primary PHB-EXP (Per-Hop Behavior-Experimental) mapping to be used by an E-LSP (EXP-Inferred-PSC LSP). This mapping is different from the node level PHB-EXP mapping.

Use the `no` parameter with this command to remove a PHB-EXP mapping configuration from current E-LSP PHB-EXP mapping.

Command Syntax

```
primary class-to-exp-bit CLASS <0-7>
no primary class-to-exp-bit CLASS <0-7>
```

Parameters

CLASS	Specify the DiffServ Class Name (for example, be, ef etc.) used for selecting incoming IP packets to be mapped to a specified RSVP trunk.
<0-7>	Exp bit which is to be mapped to this PHB.

Default

By default, primary map class is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary class-to-exp-bit af12 3

(config)#rsvp-trunk T1
(config-trunk)#no primary class-to-exp-bit af12 3
```

primary elsp-signaled

Use this command to configure a primary Diff-Serv (Differentiated Services) explicitly signaled E-LSP (EXP-Inferred-PSC LSP) interface.

The classes 1 to 7 are optional parameters that can be selected from node level PHB-EXP (Per-Hop Behavior) mapping as PHBs, which will then be used for an E-LSP. If you do not specify a class with this command, all classes will be selected for the E-LSP.

Use the no parameter with this command to remove the configuration.

Command Syntax

```
primary elsp-signaled
primary elsp-signaled CLASS1
primary elsp-signaled CLASS1 CLASS2
primary elsp-signaled CLASS1 CLASS2 CLASS3
primary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4
primary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5
primary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5 CLASS6
primary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5 CLASS6 CLASS7
no primary elsp-signaled
```

Parameter

CLASS<0-7> Diffserv class alias. e.g.: be, ef, af11, etc.

Default

By default, primary elsp signaled is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary elsp-signaled cs2 cs5 cs6

(config)#rsvp-trunk T1
(config-trunk)#no primary elsp-signaled
```

primary llsp

Use this command to configure a primary Differentiated Services Label-Only-Inferred-PSC (Diff-Serv L-LSP) interface, which will use Diff-Serv Class as its PHB Scheduling Class (PSC).

Use the no parameter with this command to remove the Diff-Serv L-LSP configuration.

Command Syntax

```
primary llsp CLASS
no primary llsp
```

Parameters

CLASS<0-7> Diffserv class alias. e.g: be, ef, af11, etc.

Default

By default, primary llsp is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

This command is not available on QUMRAN devices.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary llsp cs4

(config)#rsvp-trunk T1
(config-trunk)#no primary llsp
```

secondary map class

Use this command to configure a secondary PHB-EXP (Per-Hop Behavior-Experimental) mapping to be used by an E-LSP (EXP-Inferred-PSC LSP). This mapping is different from the node level PHB-EXP mapping.

Use the no parameter with this command to remove a PHB-EXP mapping configuration from current E-LSP PHB-EXP mapping.

Command Syntax

```
secondary map class-to-exp-bit CLASS <0-7>
no secondary map class-to-exp-bit CLASS <0-7>
```

Parameters

CLASS	Diff-Serv class (queue) mapped to the particular PHB. Diffserv class alias e.g: be, ef, af11, etc.
<0-7>	Exp bit that is to be mapped to this PHB.

Default

By default, secondary map class is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary class-to-exp-bit cs4 3

(config)#rsvp-trunk T1
(config-trunk)#no secondary class-to-exp-bit cs4 3
```

secondary elsp-signaled

Use this command to configure a secondary Diff-Serv (Differentiated Services) explicitly signaled E-LSP (EXP-Inferred-PSC LSP) interface. The classes 1 to 7 are optional parameters can be selected from the node level PHB-EXP (Per-Hop Behavior) mapping as PHBs. They will then be used for an E-LSP. If you do not specify a class with this command, all classes will be selected for the E-LSP.

Use the no parameter with this command to remove the configuration.

Command Syntax

```
secondary elsp-signaled
secondary elsp-signaled CLASS1
secondary elsp-signaled CLASS1 CLASS2
secondary elsp-signaled CLASS1 CLASS2 CLASS3
secondary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4
secondary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5
secondary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5 CLASS6
secondary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5 CLASS6 CLASS7
no secondary elsp-signaled
```

Parameters

CLASS<0-7> Diffserv class alias. e.g: be, ef, af11, etc.

Default

By default, secondary elsp signaled is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary elsp-signaled class cs3 cs6 cs2 cs5

(config)#rsvp-trunk T1
(config-trunk)#no secondary elsp-signaled
```

secondary llsp

Use this command to configure a secondary Differentiated Services Label-Only-Inferred-PSC (Diff-Serv L-LSP) interface, which will use Diff-Serv Class as its PHB Scheduling Class (PSC).

Use the no parameter with this command to remove the Diff-Serv L-LSP configuration.

Command Syntax

```
secondary llsp CLASS
no secondary llsp
```

Parameters

CLASS<0-7> Diffserv class alias. e.g: be, ef, af11, etc.

Default

By default, secondary llsp is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

This command is not available on QUMRAN devices.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary llsp class cs5

(config)#rsvp-trunk T1
(config-trunk)#no secondary llsp
```


show rsvp diffserv-info

Use this command to display node level Differentiated Services (Diff-Serv) configuration information. This information includes the node level PHB-EXP mapping configured for ELSP-signaled LSP.

Command Syntax

```
show rsvp diffserv-info
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

Following is a sample output of the `show rsvp diffserv-info` command.

```
#show rsvp diffserv-info
CLASS-EXP mapping:
CLASS      DSCP_value
c5  101000 0
be  000000 1
cs1 001000 2
cs3 011000 3
cs2 010000 4
cs4 100000 5
cs6 110000 6
cs7 111000 7
```

[Table 5-1](#) explains the show command output fields.

Table 5-1: show rsvp diffserv-info output fields

Field	Description
CLASS	MPLS class type that corresponds to the DiffServ traffic engineering class.
EXP_value	Exp value is initialized at the ingress routing device only and overrides the rewrite configuration established for that forwarding class.

CHAPTER 6 RSVP Multipath Commands

This chapter is a reference for RSVP Multipath commands:

- [description](#)
- [multipath-group](#)
- [rsvp-multipath](#)
- [to A.B.C.D](#)
- [show mpls counters rsvp multipath-name](#)
- [show mpls rsvp-multipath](#)
- [show rsvp multipath](#)
- [show running-config rsvp-multipath](#)

description

Use this command to add a description to the multipath group or update an existing description.

Use the `no` parameter to remove the description.

Command Syntax

```
description LINE
no description
```

Parameter

LINE	Line describing the purpose of RSVP multipath Group
------	---

Default

By default, description is empty.

Command Mode

Multipath mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#rsvp-multipath mygroup
(config-multipath)# description "For example purpose"
(config-multipath)# no description
```

multipath-group

Use this command to configure a multipath group on the RSVP trunk. When multipath group is configured on the trunk, trunk will become member of multipath group.

Use the `no` parameter to remove multipath group from RSVP trunk.

Command Syntax

```
multipath-group GROUPNAME
no multipath-group
```

Parameter

GROUPNAME	Name of the multipath group
-----------	-----------------------------

Default

By default, parameter is not configured.

Command Mode

Trunk mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#rsvp-trunk to_dest1
(config-trunk)# multipath-group mygroup
(config-trunk)# no multipath-group
```

rsvp-multipath

Use this command to create a new multipath group or enter the existing group to update any group parameter.

Use the `no` parameter with this command to remove an RSVP multipath group.

Command Syntax

```
rsvp-multipath GROUPNAME
no rsvp-multipath GROUPNAME
```

Parameter

GROUPNAME	Name of the multipath group
-----------	-----------------------------

Default

By default, rsvp multipath is not configured.

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

The command prompt changes from config to config-multipath as illustrated below:

```
#configure terminal
#(config)#rsvp-multipath mygroup
#(config-multipath)#exit
#(config)#no rsvp-multipath mygroup
```

to A.B.C.D

Use this command to specify an IPv4 egress to a multipath group. When configuring a multipath group, you must specify the address of the egress router by using this command. An egress definition is a mandatory attribute; multipath group is not allowed to be configured on RSVP trunks when an egress is not defined.

Use the no parameter to remove the IPv4 egress address from multipath group.

Command Syntax

```
to A.B.C.D
no to
```

Parameter

A.B.C.D IPv4 address of multipath group destination

Default

By default, parameter is not configured.

Command Mode

Multipath mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#rsvp-multipath mygroup
(config-multipath)# to 3.3.3.3
(config-multipath)# no to
```

show mpls counters rsvp multipath-name

Use this command to get traffic statistics over member trunks of multipath group.

Note: Qumran devices require hardware statistics profiles to be enabled explicitly for traffic statistics to be active. For tunnel statistics 'tunnel-lif' statistics profiles need to be enabled and system needs to be reloaded to take effect. Please see the `hardware-profile statistics` command in the *OcNOS Configuration Guide* for details.

Note: This statistic is not an explicit count of traffic over a multipath group. This statistic is collected over multipath members individually and any traffic individually carried by multipath members also counted under this output.

Command Syntax

```
show mpls counters rsvp multipath-name (NAME|)
```

Parameter

NAME	RSVP multipath group name
------	---------------------------

Command Mode

Exec mode and Privilege Exec mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#show mpls counters rsvp multipath-name test
Tunnel-id 5001 Extended Tunnel-ID 1.1.1.1 Egress 2.2.2.2
  lsp-name : t1-Primary                                [Ingress]
  lsp-ingress : 1.1.1.1                                lsp-id : 2201
  Rx pkts : n/a                                         Rx bytes : n/a
  Tx pkts : 3776248                                     Tx bytes : 5671925998

Tunnel-id 5002 Extended Tunnel-ID 1.1.1.1 Egress 2.2.2.2
  lsp-name : t2-Primary                                [Ingress]
  lsp-ingress : 1.1.1.1                                lsp-id : 2202
  Rx pkts : n/a                                         Rx bytes : n/a
  Tx pkts : 3776250                                     Tx bytes : 5671927500
```

show mpls rsvp-multipath

Use this command to display forwarder level information for a multipath group or all multipath groups.

Command Syntax

```
show mpls rsvp-multipath (NAME|)
```

Parameter

NAME RSVP multipath group name

Command Mode

Exec mode and Privilege Exec mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
# show mpls rsvp-multipath
Codes: > - installed FTN, * - selected FTN, t - tunnel, R - RSVP-TE FTN
```

```
Multipath Name : mp1, ID : 101, Nhlfe Ix : 2
Active member count : 2, FEC : 2.2.2.2/32
Active member details :
```

Index	Code	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	ELC	Nexthop
1	R(t)>	1	1	5002	Yes	LSP_DEFAULT	24320	xe31	No	31.1.1.2
2	R(t)>	2	3	5001	Yes	LSP_DEFAULT	24321	xe11	No	11.1.1.2

show rsvp multipath

Use this command to display information for a multipath group or all multipath groups.

Command Syntax

```
show rsvp multipath (NAME|)
```

Parameter

NAME	RSVP multipath group name
------	---------------------------

Command Mode

Exec mode and Privilege Exec mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#show rsvp multipath
```

```
RSVP-multipath Name : mp1, ID : 101
Description : "multipath group from R1 to R2"
Member count : 3, Egress : 2.2.2.2/32
Member details :
-----
Trunk-ID   Trunk-name           Status
5001       to_R2_1               active
5002       to_R2_2               active
5003       to_R2_3               inactive
```

```
RSVP-multipath Name : mp2, ID : 102
Member count : 0, Egress : 3.3.3.3/32
```

```
RSVP-multipath Name : mp3, ID : 103
Member count : 0, Egress : N/A
```

show running-config rsvp-multipath

Use this command to check configuration details of multipath groups.

Command Syntax

```
show running-config rsvp-multipath (NAME|)
```

Parameter

NAME	Name of the multipath group
------	-----------------------------

Command Mode

Exec mode and Privilege Exec mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#show running-config rsvp-multipath
!
rsvp-multipath mp1
  description "multipath group from R1 to R2"
  to 2.2.2.2
!
rsvp-multipath mp2
  to 3.3.3.3
!
rsvp-multipath mp3
!
!
```

CHAPTER 7 Show Commands

This chapter describes the RSVP-TE show commands.

- [Show Commands - RSVP Auto Bypass](#)
- [show debugging rsvp](#)
- [show rsvp](#)
- [show rsvp admin-groups](#)
- [show rsvp bypass](#)
- [show rsvp bypass detail](#)
- [show rsvp bypass lsp-address-list](#)
- [show rsvp bypass protected-lsp-list](#)
- [show rsvp control-adjacency](#)
- [show rsvp data-link](#)
- [show rsvp graceful-restart](#)
- [show rsvp interface](#)
- [show rsvp l2-info](#)
- [show rsvp label-pool](#)
- [show rsvp local-addresses](#)
- [show rsvp neighbor](#)
- [show rsvp nexthop-cache](#)
- [show rsvp path](#)
- [show rsvp protected-lsp-reop-list](#)
- [show rsvp session](#)
- [show rsvp session count](#)
- [show rsvp session egress](#)
- [show rsvp session ingress](#)
- [show rsvp session LSP-NAME](#)
- [show rsvp session transit](#)
- [show rsvp statistics](#)
- [show rsvp summary-refresh](#)
- [show rsvp trunk](#)
- [show rsvp trunk multi-sec-detail](#)
- [show rsvp version](#)

show debugging rsvp

This command displays the status of the options selected by the `debug rsvp` command.

Command Syntax

```
show debugging rsvp
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show debugging rsvp
NSM debugging status:
  RSVP event debugging is on
  RSVP packet debugging is on
  RSVP incoming packet debugging is on
  RSVP outgoing packet debugging is on
  RSVP hexadecimal dump debugging is on
#
```

[Table 7-2](#) explains the show command output fields.

Table 7-2: show debugging rsvp output fields

Field	Description
NSM debugging status	Debugging is enabled or disabled on a per-interface basis, using the commands.

show rsvp

Use this command to display data about the RSVP daemon.

Command Syntax

```
show rsvp
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp
RSVP Version           : 1
Process uptime         : 8 minutes
RSVP Refresh Reduction : Enabled
RSVP Message Acknowledgement : Disabled
Bundle Send            : Disabled
NSM Connection         : Up
CSPF Connection        : Up
CSPF usage              : Enabled
RSVP Refresh Timer     : 5
Keep Multiplier        : 3
Acknowledgement Await Timeout : 10
Explicit-Null For Direct Conn : Disabled
Local Protection       : Disabled
Hello Receipt          : Disabled
Hello Interval         : 2
Hello Timeout          : 10
Loop detection         : Enabled (all interface)
Override Diffserv      : Disabled
Ingress                : 1.1.1.1
Penultimate Hop Popping : Enabled
Refresh PATH msg parsing : Enabled
Refresh RESV msg parsing : Enabled
Detour identification   : Sender-Template

#
```

[Table 7-3](#) explains the show command output fields.

Table 7-3: show rsvp output fields

Field	Description
RSVP Version	Version number associated with the RSVP ingress route.
Process uptime	Duration of the process running time.
RSVP Refresh Reduction	Measure of processing over head requests of refresh messages. Refresh reduction detail extensions improve routing device performance by reducing the process overhead, thus increasing the number of LSPs a routing device can support.
RSVP Message Acknowledgement	Acknowledge message for refresh reductions.
Bundle Send	Disables sending of Bundle Messages for a system.
NSM Connection	The Network Services Module (NSM) sends unsolicited messages to, or receives unsolicited messages from, the QoS (quality of service) module.
CSPF Connection	NSM passes the information to CSPF.
CSPF usage	CSPF finds the shortest path toward the LSP's egress router, taking into account explicit-path constraints.
RSVP Refresh Timer	Time interval used to generate periodic RSVP messages.
Keep Multiplier	Number of RSVP messages that can be lost before an RSVP state is declared stale.
Acknowledgment Await Timeout	The router that initiates the acknowledgment messages for an RSVP session waits for the timeout.
Explicit-Null For Direct Conn	Advertise label 0 to the egress routing device of an LSP. Explicit null: enabled or disabled.
Local Protection	A local repair mechanism is in use to maintain this tunnel.
Hello Receipt	To exchange Hello messages among neighbors.
Hello Interval	Frequency at which RSVP hellos are sent on this interface (in seconds).
Hello Timeout	RSVP Hello State Timer feature detects when a neighbor is down and triggers faster state timeout.
Loop detection	Loop back Detection (LBD) provides protection against loops by transmitting loop protocol packets out of ports where loop protection has been enabled.
Override Diffserv	Diffserv helps to carry the EXP-to-PHB mapping for signaled E-LSP or the PSC value for L-LSP.
Ingress	Information about ingress RSVP sessions.
Penultimate Hop Popping	Removes the label one hop before its destination.
Refresh PATH msg parsing	Refresh message supports the refreshing of RSVP state without the transmission of conventional Path messages.
Refresh RESV msg parsing	Refresh message supports the refreshing of RSVP state without the transmission of conventional Resv messages.
Detour identification	Detours are calculated to avoid the immediate downstream link and node.

show rsvp admin-groups

Use this command to display all known administrative groups configured through the NSM for the system.

Command Syntax

```
show rsvp admin-groups
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

This is a sample output showing four administrative groups configured through NSM.

```
#show rsvp admin-groups
Admin group detail:
  Value of 0 associated with admin group 'a'
  Value of 1 associated with admin group 'b'
  Value of 2 associated with admin group 'c'
  Value of 3 associated with admin group 'd'
#
```

[Table 7-4](#) explains the show command output fields.

Table 7-4: show rsvp admin-groups output field

Field	Description
Admin group detail	Administrative groups details which implements the link coloring of resource classes.

show rsvp bypass

Use this command to display bypass session related information for configured bypass LSPs.

Command Syntax

```
show rsvp bypass
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp bypass
Ingress RSVP:
To           From           Tun-ID   LSP-ID   LSPName                               State Uptime      Rt  Style  Labelin  Labelout
172.31.54.4   172.31.54.1     5001     2201     BYPASS2-172.31.222.19-Bypass          UP    02d15h11m  1 1 SE    -        52516
172.31.54.2   172.31.54.1     5002     2202     BYPASS3-172.31.222.9-Bypass           UP    02d15h11m  1 1 SE    -         0
172.31.54.2   172.31.54.1     5003     2203     BYPASS4-172.31.222.7-Bypass           UP    02d15h11m  1 1 SE    -         0
172.31.53.18  172.31.54.1     5004     2204     BYPASS5-172.31.189.179-Bypass          UP    02d15h11m  1 1 SE    -        52501
```

show rsvp bypass detail

Use this command to display bypass session related information in detail for all configured bypass LSPs or the bypass session with specified bypass tunnel name.

Command Syntax

```
show rsvp bypass (BYPASSNAME | detail)
```

Parameters

BYPASSNAME	Bypass tunnel name
detail	Detailed information of all configured bypass sessions

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp bypass BYPASS2-172.31.222.19
Ingress (Bypass)
172.31.54.4
  From: 172.31.54.1, LSPstate: Up, LSPname: BYPASS2-172.31.222.19-Bypass
  Ingress FSM state: Operational
  Establishment Time: 0s 324ms
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
  IGP-Shortcut: Disabled, LSP metric: 1
  LSP Protection: None
  Bypass trunk bandwidth type: Best-effort
    Label in: -, Label out: 52516,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 172.31.54.1
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 172.31.222.25, po22
  Path refresh: 30 seconds (RR enabled) (due in 12409 seconds)
  Resv lifetime: 157 seconds (due in 130 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: none
  Exclude Link: 172.31.222.19
  Session Explicit Route Detail :
    172.31.222.25/32 strict
    172.31.180.3/32 strict
    172.31.180.4/32 strict
  Record route:
  -----
  IP Address          Label
  -----
```

```
<self>
172.31.222.25
172.31.180.3
172.31.180.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 9174
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Last Signaled Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Total LSP protected : 0, Bandwidth in use : 0
```

show rsvp bypass lsp-address-list

Use this command to display address details of every node of a bypass session shown as merge node detail for egress node of bypass session and transit node detail for transit node details of bypass session.

Command Syntax

```
show rsvp bypass (BYPASSNAME|) lsp-address-list
```

Parameters

BYPASSNAME (Optional) Bypass tunnel name

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp bypass BYPASS2-172.31.222.19 lsp-address-list
Bypass trunk: BYPASS2-172.31.222.19

Merge Point Router ID: 172.31.54.4

Number of Merge Point IP addresses: 6
IP address:
  172.31.222.22      172.31.180.4      172.31.222.19      172.31.222.27
  172.31.222.31      172.31.186.4

Number of Transit Point IP addresses: 9
IP address:
  172.31.54.3        172.31.222.23      172.31.222.30      172.31.180.2
  172.31.222.25      172.31.186.20      172.31.33.120      172.31.180.3
  172.31.180.5

LSP address query interval: 60 seconds, next retry in: 27 seconds
```

show rsvp bypass protected-lsp-list

Use this command to display the list of sessions protected by a bypass session and match code provides the details bypass is a perfect match or any constraint compromised.

Note: Match code 0 is an indication of perfect match i.e. all constraint of protected session matched. i.e. If protected session asked for node protection, then bypass provides perfect node protection by merging exactly at next to next hop node. If protected session asked for bandwidth protection, bypass provides bandwidth protection. In case of PHP node, even when node protection is requested by protected session, it is not applicable and node protection request is not applicable on PHP node. Thus, a bypass providing link protection with other criteria matching is considered as perfect match.

Note: If a bypass protected session requested for link protection but it is mapped to a bypass node protection, then it is not a perfect match. Match code will be 4 in that case.

Note: When bandwidth protection is requested, highest importance of bypass mapping given to bandwidth protection. When bandwidth protection cannot be provided, then the remaining constraints given importance.

Command Syntax

```
show rsvp bypass (BYPASSNAME|) protected-lsp-list
```

Parameters

BYPASSNAME Bypass tunnel name

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp bypass protected-lsp-list
Match Code: 0 - Perfect match (all criteria matching), 1 - Bandwidth protection miss, 2 - Node protection miss,
            3 - SRLG protection miss, 4 - Merge point not ideal, 255 - Invalid

Bypass trunk: BYPASS2-172.31.222.19
Bypass trunk bandwidth type: best-effort
Total LSP protected : 0
Bandwidth in use : 0

Bypass trunk: BYPASS3-172.31.222.9
Bypass trunk bandwidth type: best-effort
List of LSP's Protected:
Tunnel-id  Lsp-Id    Lsp-Name                               Role    Ext_tnl_id    Ingress          Egress           Match-Code
61976      3         to_OKL_STRICT                         Transit  172.31.2.52    172.31.2.52      172.31.54.2      0
61975      4         to_OKL_2ND_LOOSE                      Transit  172.31.2.52    172.31.2.52      172.31.54.2      0
20         23884     to_OKL_1ST_LOOSE::to_OKL_1ST_LOOSE    Transit  172.31.33.120  172.31.33.120    172.31.54.2      0
22         5478      to_OKL_2ND_LOOSE::to_OKL_2ND_LOOSE    Transit  172.31.33.120  172.31.33.120    172.31.54.2      0
61974      3         to_OKL_1ST_LOOSE                      Transit  172.31.2.52    172.31.2.52      172.31.54.2      0
21         36172     to_OKL_STRICT::to_OKL_STRICT          Transit  172.31.33.120  172.31.33.120    172.31.54.2      0
Total LSP protected : 6
Bandwidth in use : 0
```

show rsvp control-adjacency

Use this command to display RSVP specific information for control adjacency.

Command Syntax

```
show rsvp control-adjacency
show rsvp control-adjacency CANAME
```

Parameters

CANAME Use this parameter to display the name of a control-adjacency

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#"show rsvp control-adjacency" without parameters:
Control Adj      Admin status   Oper Status      Peer-address      Gifindex
Control Channel

#"show rsvp control-adjacency" with parameters:
Admin Status"Enabled" : "Disabled"
Oper Status"Up" : "Down"
Peer-address
Gifindex
Control-Channel in usecc->name : "N/A"
Control-Channel Gifindex
Control-Channel Local-address
Control-Channel Peer-address
Control-Channel ID
Control-Channel Binding Ifindex
Refresh Reduction usage"Disabled" : "Enabled"
Message Acknowledgement"Enabled" : "Disabled"
Bundle Buffer size
Current Epoch Value
Primary IPv4 addressIPv4_address : "N/A"
Primary IPv6 addressIPv6_address : "N/A"
Configured refresh time
Configured keep multiplier
Acknowledgement Await Timeout
Hello Receipt"Enabled" : "Disabled"
Hello Interval
Hello Timeout
Non IANA Hello exchange"Enabled" : "Disabled"
```

[Table 7-5](#) explains the show command output fields.

Table 7-5: show rsvp control-adjacency output field

Field	Description
Control Adj	Control Adjacency status and configuration.
Admin status	Indicates whether the user can administratively disable a peer while still preserving its configuration. Up = Yes, Down = No.
Oper Status	Displays the current status of the cross-connect segment – Up or Down.
Peer-address	Peer address in aa IPv4 and IPv6 format.
Gifindex	Number of gif index on which RSVP is active.
Control Channel	Control Channel status and configuration.
Refresh Reduction usage	Measure of processing over head requests of refresh messages.
Message Acknowledgment	The router that initiates the acknowledgment messages for an RSVP session.
Bundle Buffer size	Number of bundle buffer size.
Current Epoch Value	Value of the database epoch and number of entries in the epoch.
Primary IPv4 address	Primary IPv4 address of the neighbor interface.
Primary IPv6 address	Primary IPv6 address of the neighbor interface.
Configured Refresh Time	Time refresher which takes to generate periodic RSVP messages.
Configured Keep Multiplier	Number of RSVP messages that can be lost before an RSVP state is declared stale.
Acknowledgment Await Timeout	The router that initiates the acknowledgment messages for an RSVP session waits for the timeout.
Hello Receipt	To exchange Hello messages among neighbors.
Hello Interval	Frequency at which RSVP hellos are sent on this interface (in seconds).
Hello Timeout	RSVP Hello State Timer feature detects when a neighbor is down and triggers faster state timeout.
Non IANA Hello exchange	Hello exchange state in the interface.

show rsvp data-link

Use this command to display RSVP specific information for data links.

Command Syntax

```
show rsvp data-link
show rsvp data-link DLNAME
```

Parameters

DLNAME	Data link name
--------	----------------

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#sh rsvp data-link
```

show rsvp graceful-restart

To modify the lines displayed, use the | (output modifier token); to save the output to a file, use the > output redirection token.

Command Syntax

```
show rsvp graceful-restart
show rsvp graceful-restart A.B.C.D
```

Parameters

A.B.C.D IPv4 address of a specific neighbor (optional).

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#show rsvp graceful-restart
Graceful Restart: Enabled
Advertised Restart Time: 180000 msec
Advertised Recovery Time: 360000 msec
Sending Recovery Time: Yes
Remote addr: 172.16.10.2 Local addr: 172.16.10.1
Nbr State: Normal Type: Reroute
Nbr Hello State: Up
LSPs protecting: 0
Restart Time: 0 msec, Recovery Time: 0 msec
Rest of Restart Time: 0 msec, Rest of Recovery Time: 0 msec
```

show rsvp interface

Use this command to display data about RSVP-specific information for interfaces, or about a specific interface.

Command Syntax

```
show rsvp interface
show rsvp interface IFNAME
```

Parameter

IFNAME The name of the interface to display data.

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp interface eth0
Status                               : Enabled
Interface Index                      : 2
Refresh Reduction usage              : Enabled
Message Acknowledgement             : Disabled
Bundle Buffer size                    : 65535
Current Epoch Value                  : 208043005
Primary IPv4 address                 : 10.10.23.1
Primary IPv6 address                 : N/A
Interface Type                       : Ethernet
Administrative Group                  : a
                                     : d
Configured refresh time               : 5
Configured keep multiplier            : 3
Acknowledgement Await Timeout        : 10
Hello Receipt                        : Disabled
Hello Interval                       : 2
Hello Timeout                        : 10
Non IANA Hello exchange               : Disabled
#
```

[Table 7-6](#) explains the show command output fields.

Table 7-6: show rsvp interface output field

Field	Description
Status	Display the status of Resource Reservation Protocol (RSVP).
Interface Index	Number of interface index on which RSVP is active.
Refresh Reduction usage	Measure of processing over head requests of refresh messages.

Table 7-6: show rsvp interface output field

Field	Description
Message Acknowledgement	The router that initiates the acknowledgment messages for an RSVP session.
Bundle Buffer size	Number of bundle buffer size.
Current Epoch Value	Value of the database epoch and number of entries in the epoch.
Primary IPv4 address	Primary IPv4 address of the neighbor interface.
Primary IPv6 address	Primary IPv6 address of the neighbor interface.
Interface Type	Type of interface.
Administrative Group	The administrators who belong to the same administrative group.
Configured Refresh Time	Time refresher which takes to generate periodic RSVP messages.
Configured Keep Multiplier	Number of RSVP messages that can be lost before an RSVP state is declared stale.
Acknowledgment Await Timeout	The router that initiates the acknowledgment messages for an RSVP session waits for the timeout.
Hello Receipt	To exchange Hello messages among neighbors.
Hello Interval	Frequency at which RSVP hellos are sent on this interface (in seconds).
Hello Timeout	RSVP Hello State Timer feature detects when a neighbor is down and triggers faster state timeout.
Non IANA Hello exchange	Hello exchange state in the interface.

show rsvp l2-info

Use this command to display MAC and out interface details of a bypass tunnel which is used to send control messages of protected sessions over bypass tunnel when protected session is using backup.

Command Syntax

```
show rsvp l2-info
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp l2-info
=====
## Bypass ftn l2 info ##
Ftn IX: 1
Out label: 52521 Out if 100022
src addr:(34ef.b63d.57a9)
Dst addr:(34ef.b694.3e08)
=====
## Bypass ftn l2 info ##
Ftn IX: 2
Out label: 3 Out if 100022
src addr:(34ef.b63d.57a9)
Dst addr:(34ef.b694.3e08)
=====
```

show rsvp label-pool

Use this command to display the label management in RSVP protocol.

Command Syntax

```
show rsvp label-pool (block-id <0-1638>|)
```

Parameters

block-id Block identifier of a block that is allocated to the protocol

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 6.5.4.

Example

```
#show rsvp label-pool
Module: RSVP, Label range: 16-1048575, Current block: 45
+-----+-----+-----+-----+-----+-----+-----+
---+
block_id label_min label_max usable_labels free_labels first_free_label
+-----+-----+-----+-----+-----+-----+-----+
---+
44 28160 28799 640 0 0
45 28800 29439 640 96 29344
Total - blocks: 2, used-labels: 1184, free-labels: 96
```

show rsvp local-addresses

Use this command to display data about any configured RSVP local address, including either IPv4 or IPv6 addresses.

Command Syntax

```
show rsvp local-addresses
show rsvp local-addresses ipv4
show rsvp local-addresses ipv6
```

Parameters

ipv4	Use this parameter to display IPv4 local addresses.
ipv6	Use this parameter to display IPv6 local addresses.

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp local-addresses
IPv4 Addresses:
Address                Interface
4.4.4.40               lo
10.1.2.40              eth0
14.14.14.8             eth4
34.0.0.40              eth2
80.0.0.40              eth2
127.0.0.1              lo
IPv6 Addresses:
Address                Interface
::1                   lo
fe80::202:b3ff:fed5:8dbb eth4
fe80::202:b3ff:fed5:9842 eth2
fe80::20e:cff:fe83:3727  eth0
#
```

[Table 7-7](#) explains the show command output fields.

Table 7-7: show rsvp local-addresses output field

Field	Description
IPv4 Addresses	IPv4 address for the interface.
IPv6 Addresses	IPv6 address for the interface.
Address	Address for the interface.
Interface	Name of the interface.

show rsvp neighbor

Use this command to display a list of IPv4 RSVP neighbors or just a single IPv4 RSVP neighbor.

Command Syntax

```
show rsvp neighbor
show rsvp neighbor A.B.C.D
```

Parameters

A.B.C.D Use this parameter to display the IP address of the IPv4 RSVP neighbor.

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp neighbor
IP Address          UpStrm LSP DnStrm LSP RefreshReduc Srefresh In  Type
10.10.20.4          0          1          Enabled      5s          Implicit
10.10.23.2          0          1          Enabled      8s          Implicit
#
```

[Table 7-8](#) explains the show command output fields.

Table 7-8: show rsvp neighbor output field

Field	Description
IP Address	Address for the interface.
UpStrm LSP	Specify the upstream label for the bidirectional label-switched path (LSP).
DnStrm LSP	Specify the dnstream label for the bidirectional label-switched path (LSP).
Refresh Reduc	Refresh reduction improves the scalability, latency, and reliability of Resource Reservation Protocol (RSVP) signaling to enhance network performance and message delivery.
Srefresh In	Remaining seconds for srefresh timer expiry.
Type	Type of neighbor interface.

show rsvp nexthop-cache

Use this command to display the current nexthops being cached by RSVP.

Command Syntax

```
show rsvp nexthop-cache
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp nexthop-cache
Prefix          Nexthop          Outgoing Intf  Valid For      Num Sessions
10.10.20.80/32   0.0.0.0          eth1           12 seconds    1
10.10.23.60/32   0.0.0.0          eth0           17 seconds    1
#
```

[Table 7-9](#) explains the show command output fields.

Table 7-9: show rsvp nexthop-cache output field

Field	Description
Prefix	It is an ordered list and entries are evaluated in order of increasing sequence number.
Nexthop	IP address of the next hop.
Outgoing Intf	Short name of the physical interface through which traffic goes to the protected link.
Valid For	Frequency at which RSVP hellos are sent next hop on this interface (in seconds).
Num Sessions	Number of session in the interface.

show rsvp path

Use this command to display the configured rsvp paths and their configured hops. Specify the pathname to show hops related to a specific path. If no pathname is specified all the rsvp paths are displayed.

Command Syntax

```
show rsvp path
show rsvp path PATHNAME
```

Parameter

PATHNAME	The name of a specific path.
----------	------------------------------

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

Following are sample outputs from this command, with and without a `PATHNAME` (PRI) specified.

```
#show rsvp path
Path name: PRI, id: 1
 10.10.11.51 strict
 10.10.12.50 strict
 10.10.13.51 strict

Path name: SEC, id: 2
 10.10.10.51 strict

Path name: loop, id: 3
 10.10.11.51 strict
 10.10.12.50 strict
 10.10.13.51 strict
 10.10.14.50 strict
#

#show rsvp path PRI
Path name: PRI, id: 1
 10.10.11.51 strict
 10.10.12.50 strict
 10.10.13.51 strict
#
```

[Table 7-10](#) explains the show command output fields.

Table 7-10: show rsvp path output field

Field	Description
Path name	Name of the path.
id	Address of the rsvp path.

show rsvp protected-lsp-reop-list

Use this command to display list of facility protected sessions which didn't get any bypass protection or didn't get a perfect bypass protection. These sessions are checked for better protection whenever a new bypass session comes up.

Command Syntax

```
show rsvp protected-lst-reop-list
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp protected-lsp-reop-list
```

Tunnel-id	Lsp-Id	Lsp-Name	Role	Ext_tnl_id	Ingress	Egress	Protected
222	169	LHR_t222	Transit	172.31.53.18	172.31.53.18	172.31.2.52	Yes
204	1522	LHR_t204	Transit	172.31.53.18	172.31.53.18	172.31.33.120	Yes
17	52608	GGN_NDLS_2ND_LOOSE::to_CISCO_2ND_LOOSE	Transit	172.31.33.120	172.31.33.120	172.31.53.18	Yes

show rsvp session

Use this command to display session-related information for configured LSPs.

Command Syntax

```
show rsvp session
show rsvp session up
show rsvp session up detail
show rsvp session down
show rsvp session down detail
```

Parameters

up	Use this parameter to display sessions that are currently operational.
down	Use this parameter to display sessions that are currently not operational.
detail	Use this parameter to display detailed session-related information.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

Following is a sample output from the command using the detail parameter.

```
#show rsvp session detail
Ingress (Primary)
10.10.21.3
  From: 1.1.1.1, LSPstate: Up, LSPname: t1
  Setup priority: 5, Hold priority: 5
  CSPF usage: Disabled
  LSP Protection: None
  Label in: -, Label out: 16,
  Tspec rate: 10m, Fspec rate: 10m
  Tunnel Id: 1, LSP Id: 2, Ext-Tunnel Id: 1.1.1.1
  Downstream: 10.10.23.2, eth0
  Path refresh: 5 seconds (due in 6772 seconds)
  Resv lifetime: 26 seconds (due in 25 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: p1 (in use)
  Configured Explicit Route Detail :
    10.10.23.2/32 strict
  Session Explicit Route Detail :
    10.10.23.2/32 strict
  Record route: <self> 10.10.23.2 10.10.21.3
  Style: Shared Explicit Filter
  Traffic type: controlled-load
```

```

Minimum Path MTU: 1500
LSP Type:  ELSP_SIGNAL
CLASS      DSCP_value      EXP_value
#

```

Table 7-11 explains the show command output fields.

Table 7-11: show rsvp session output field

Field	Description
Ingress (Primary)	Information about ingress RSVP sessions. Each session has one line of output.
From	Source (ingress switch) of the session.
LSP state	State of the LSP that is being handled by this RSVP session. It can be either Up, Dn (down), or Admin Dn. Admin Dn indicates that the LSP is being taken down gracefully.
LSPname	Name of the LSP.
Setup priority	Value of the setup priority.
Hold priority	Determines the degree to which an LSP holds onto its session reservation after the LSP has been set up successfully.
CSPF usage	CSPF usage state in the rsvp session.
LSP Protection	Protects the traffic failures.
Label in	Incoming label for this LSP.
Label out	Outgoing label for this LSP.
Tspec rate	Sender's traffic specification, which describes the sender's traffic parameters.
Fspec rate	Fspec peak rate values.
Tunnel id	Tunnel address (destination port) for the session.
LSP id	Address of the LSP in the interface.
Ext-Tunnel Id	Session address for the ext-tunnel.
Down stream	Specify the dnstream label for the bidirectional label-switched path (LSP).
Path refresh	Path messages are sent periodically to refresh path states. The refresh interval is controlled by a variable called the refresh time.
Resv lifetime	Number of seconds remaining in the lifetime of the reservation.
Retry count	Number of times sanity polling periodically checks for an error condition in the FPC.
intrvl	Interval sets the time for the messages in order to control the session.
LSP Type	Type of ELSP signal.

show rsvp session count

Use this command to display session-related information for configured LSPs.

Command Syntax

```
show rsvp session count
show rsvp session count egress
show rsvp session count ingress
show rsvp session count transit
```

Parameters

egress	Use this parameter to display the number of configured egress sessions.
ingress	Use this parameter to display the number of configured ingress sessions.
transit	Use this parameter to display the number of configured transmit sessions.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp session count
Total configured: 1520, Up 1520, Down 0
#
```

[Table 7-12](#) explains the show command output fields.

Table 7-12: show rsvp session count output field

Field	Description
Total configured	Number of configured rsvp session in the interface.

show rsvp session egress

Use this command to display session-related information for an egress router.

Command Syntax

```
show rsvp session egress
show rsvp session egress A.B.C.D
show rsvp session egress X:X::X:X
show rsvp session egress detail
show rsvp session egress down
show rsvp session egress down detail
show rsvp session egress up
show rsvp session egress up detail
```

Parameters

A.B.C.D	Use this parameter to display an IPv4 address of an egress router
X:X::X:X	Use this parameter to display an IPv6 address of an egress router
down	Use this parameter to display sessions that are currently not operational
up	Use this parameter to display sessions that are currently operational
detail	Use this parameter to display detailed session-related information

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#show rsvp session egress without parameters or with "up" or "down":
%s RSVP:
To           From           State           Pri Rt   Style Labelin
Labelout LSPName           Uptime   Est.time   DSType
...
Total %d displayed

#show rsvp session egress with parameters:
"Bypass", "Primary", "Detour", "Secondary"
Make-Before-Break Sibling for session with LSP-ID:prefix4: prefix6
From: u.prefix4: u.prefix6
LSPstate: %s, LSPname:
    "Up"/"Using Backup"/"Using Secondary"
    "Dn",
Revert hold timer is ON due to expire in %d seconds
Revert Timer Finished, Forced Switch to Secondary LSP In Effect
CSPF usage: "Disabled" : "Enabled"
, CSPF Retry Count: %d, CSPF Retry Interval: %d seconds"
IGP-Shortcut: Enabled, LSP metric:
IGP-Shortcut: Disabled, LSP metric:
```

```

LSP Protection:
Bypass trunk:
Label in:
Label out:
Tspec rate:
Fspec rate:
Policer: Configured
        and installed in hardware
        but not installed in hardware
        Not Configured
Tunnel Id: %d, LSP Id: %d
Ext-Tunnel Id:
Downstream:
Upstream:
Path refresh: %d seconds (RR enabled), (due in %d seconds)
Path lifetime: %d seconds (due in %d seconds)
Resv refresh: %d seconds (due in %d seconds)
Resv lifetime: %d seconds (due in %d seconds)
Retry count: %d, intrvl: %d seconds", # remaining, next retry in: %d
seconds",
RRO re-use as ERO: "Enabled" : "Disabled"
Label Recording: "Enabled" : "Disabled"
FRR Admin Groups/Admin Groups:
    ***admin group info***
Exclude path detail:
Exclude "Link" : "Node
Configured Path: "none" : "in use" : "not in use"
%s Explicit Route Detail "Configured" : "Received"
    "strict" : "loose"
Record route: " <self>") " ...incomplete"
Style: %s\n", rsvp_style_to_str (style));
Traffic type: "guaranteed" : "controlled-load" : "none"
Minimum Path MTU:
Traffic type: N/A
Minimum Path MTU: N/A
LSP Type: "ELSP_SIGNAL" : "ELSP_CONFIG"
CLASS      DSCP_value      EXP_value
The class to exp bits mapping is invalid.
LSP Type: L-LSP
LLSP DSCP: %d%d%d%d%d%d CLASS: %4s",
DSTE Class Type Number: Invalid, Class Type name(configured):
DSTE Class Type Number: %d, Class Type name:
Last Recorded Error Code: %s (%d)
Last Recorded Error Value: %s (%d)
Node where Last Recorded Error originated:
Trunk Type: "gmpls" : "mpls"
Tesid:
Merge Point Adderss [%d] =

```

Table 7-13 explains the show command output fields.

Table 7-13: show rsvp session egress output field

Field	Description
LSP state	State of the LSP that is being handled by this RSVP session. It can be either Up, Dn (down), or Admin Dn. Admin Dn indicates that the LSP is being taken down gracefully.
LSP name	Name of the LSP.
CSPF usage	CSPF usage state in the rsvp session.
CSPF Retry Count	Number of times CSPF tried to find the path.
CSPF Retry Interval	The interval at which CSPF retry to find the path.
IGP-Shortcut	Status of IGP shortcut for the RSVP trunk.
LSP metric	Relative/Absolute metric value of the LSP.
LSP Protection	LSP Protection configured for the RSVP trunk.
Bypass trunk	Name for the configured Bypass trunk.
Tspec rate	Sender's traffic specification, which describes the sender's traffic parameters.
Fspec rate	Fspec peak rate values.
Policer	QoS Policy configured for the RSVP trunk.
Tunnel Id	Tunnel identifier (destination port) for the RSVP session.
LSP Id	Address of the LSP in the interface.
Ext-Tunnel Id	Ext Tunnel identifier (destination port) for the RSVP session.
Down stream	Specify the dn stream label for the bidirectional label-switched path (LSP).
Upstream	Address of the previous hop for the egress session.
Path refresh	Path messages are sent periodically to refresh path states. The refresh interval is controlled by a variable called the refresh time.
Path lifetime	Number of seconds remaining in the lifetime of the reservation.
Resv refresh	Remaining time in seconds for the next Resv refresh.
Resv lifetime	Number of seconds remaining in the lifetime of the reservation.
Retry count	Number of times sanity polling periodically checks for an error condition in the FPC.
intrvl	Interval sets the time for the messages in order to control the session.
next retry in	Remaining time in seconds for the next retry.
RRO re-use as ERO	Enabling to re-use Record route as Explicit route for rsvp session.
Label Recording	Enabling to record the labels exchanged by all the peers.
FRRAdmin Groups/Admin Groups	Resource affinities associated with the rsvp session.

Table 7-13: show rsvp session egress output field

Field	Description
Exclude path detail	Detailed List of the link addresses to be excluded for RSVP Bypass session.
Exclude Link	Address of the Link to be excluded for RSVP Bypass session.
Configured Path	Configured path name associated with the rsvp session.
Record route	Established rsvp path with each hop information.
Style	Reservation style associated with the rsvp session.
Traffic type	Traffic type associated with the rsvp session.
Minimum Path MTU	Path maximum transmission unit (MTU) discovery in the interface.
LSP Type	Type of ELSP signal.
CLASS	Name of the class which is associated with rsvp session.
DSCP_value	DSCP value of diff-serv class which is associated with rsvp session.
EXP_value	EXP value of diff-serv class which is associated with rsvp sess
DSTE Class Type Number	Diff-serv class type number associated with rsvp session.
Class Type name	Diff-serv class type name associated with rsvp session.
Last Recorded Error Code	The last recorded error code for the RSVP session.
Last Recorded Error Value	The last recorded error for the RSVP session.
Node where Last Recorded Error originated	Error originated node in the rsvp session.
Trunk Type	Trunk type in the rsvp session.
Tesid	Traffic Engineering Service Instance Identifier
Merge Point Addresss	Address of the node where the Bypass LSP joins with the protected LSP.

show rsvp session ingress

Use this command to display session-related information for an ingress router.

Command Syntax

```
show rsvp session ingress
show rsvp session ingress A.B.C.D
show rsvp session ingress X:X::X:X
show rsvp session ingress detail
show rsvp session ingress down
show rsvp session ingress down detail
show rsvp session ingress up
show rsvp session ingress up detail
```

Parameters

A.B.C.D	Use this parameter to display an IPv4 address of an ingress router
X:X::X:X	Use this parameter to display an IPv6 address of an ingress router.
down	Use this parameter to display sessions that are currently not operational
up	Use this parameter to display sessions that are currently operational
detail	Use this parameter to display detailed session-related information

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#show rsvp session ingress (without parameters or with up or down:)
```

```
%s RSVP:
To          From          State          Pri Rt  Style Labelin
Labelout LSPName          Uptime  Est.time  DSType
...
Total %d displayed
```

```
#show rsvp session ingress detail
Ingress (Primary)
41.41.41.31
From: 29.29.29.29, LSPstate: Up, LSPname: t1-Primary
Ingress FSM state: Operational
Establishment Time: 0s 3ms
Setup priority: 7, Hold priority: 0
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
IGP-Shortcut: Disabled, LSP metric: 1
LSP Protection: None
Label in: -, Label out: 24320, ELC
```

```
#show rsvp session ingress (with parameters:)

"Bypass", "Primary", "Detour", "Secondary"
Make-Before-Break Sibling for session with LSP-ID:prefix4: prefix6
  From: u.prefix4: u.prefix6
LSPstate: %s, LSPname:
  "Up/"Using Backup"/"Using Secondary"
  "Dn",
  Revert hold timer is ON due to expire in %d seconds
  Revert Timer Finished, Forced Switch to Secondary LSP In Effect
  CSPF usage: "Disabled" : "Enabled"
  CSPF Retry Count: %d, CSPF Retry Interval: %d seconds"
  IGP-Shortcut: Enabled, LSP metric:
  IGP-Shortcut: Disabled, LSP metric:
  LSP Protection:
  Bypass trunk:
  Label in:
  Label out:
  Tspec rate:
  Fspec rate:
  Policer: Configured
    and installed in hardware
    but not installed in hardware
    Not Configured
  Tunnel Id: %d, LSP Id: %d
Ext-Tunnel Id:
  Downstream:
  Upstream:
  Path refresh: %d seconds (RR enabled), (due in %d seconds)
  Path lifetime: %d seconds (due in %d seconds)
  Resv refresh: %d seconds (due in %d seconds)
  Resv lifetime: %d seconds (due in %d seconds)
  Retry count: %d, intrvl: %d seconds", # remaining, next retry in: %d
seconds",
  RRO re-use as ERO: "Enabled" : "Disabled"
  Label Recording: "Enabled" : "Disabled"
  FRR Admin Groups/Admin Groups:
    ***admin group info***
  Exclude path detail:
    Exclude "Link" : "Node"
    Configured Path: "none" : "in use" : "not in use"
    %s Explicit Route Detail "Configured" : "Received"
      "strict" : "loose"
  Record route: " <self>") " ...incomplete"
  Style: %s\n", rsvp_style_to_str (style));
  Traffic type: "guaranteed" : "controlled-load" : "none"
  Minimum Path MTU:
  Traffic type: N/A
  Minimum Path MTU: N/A
  LSP Type: "ELSP_SIGNAL" : "ELSP_CONFIG"
  CLASS DSCP_value EXP_value
  The class to exp bits mapping is invalid.
  LSP Type: L-LSP
  LLSP DSCP: %d%d%d%d%d%d CLASS: %4s",
  DSTE Class Type Number: Invalid, Class Type name(configured):
  DSTE Class Type Number: %d, Class Type name:
  Last Recorded Error Code: %s (%d)
```

```

Last Recorded Error Value: %s (%d)
Node where Last Recorded Error originated:
Trunk Type: "gmpls" : "mpls"
Tesid:
Merge Point Address [%d] =

```

```
#show mpls forwarding-table
```

```

Codes: > - installed FTN, * - selected FTN, p - stale FTN, B - BGP FTN, K -
CLI FTN, t - tunnel
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

```

```

Code      FEC          FTN-ID Tunnel-id  Pri  LSP-Type  Out- Label  ELC  Out-
Intf  Nexthop
R(t)> 2 9.29.29.29/32  1    5001      Yes LSP_DEFAULT  24322  yes
eth2   1.41.41.31
R(t)> 29.29.29.29/32  2    5001      No  LSP_DEFAULT  4322   yes
eth1   69.69.69.42

```

Table 7-14 explains the show command output fields.

Table 7-14: show rsvp session ingress output field

Field	Description
LSP state	State of the LSP that is being handled by this RSVP session. It can be either Up, Dn (down), or Admin Dn. Admin Dn indicates that the LSP is being taken down gracefully.
LSP name	Name of the LSP.
CSPF usage	CSPF usage state in the rsvp session.
CSPF Retry Count	Number of times CSPF tried to find the path.
CSPF Retry Interval	The interval at which CSPF retry to find the path.
IGP-Shortcut	Status of IGP shortcut for the RSVP trunk.
LSP metric	Relative/Absolute metric value of the LSP.
LSP Protection	LSP Protection configured for the RSVP trunk.
Bypass trunk	Name for the configured Bypass trunk.
Tspec rate	Sender's traffic specification, which describes the sender's traffic parameters.
Fspec rate	Fspec peak rate values.
Policer	QoS Policy configured for the RSVP trunk.
Tunnel Id	Tunnel identifier (destination port) for the RSVP session.
LSP Id	Address of the LSP in the interface.
Ext-Tunnel Id	Ext Tunnel identifier (destination port) for the RSVP session.
Down stream	Specify the dn stream label for the bidirectional label-switched path (LSP).

Table 7-14: show rsvp session ingress output field

Field	Description
Upstream	Address of the previous hop for the egress session.
Path refresh	Path messages are sent periodically to refresh path states. The refresh interval is controlled by a variable called the refresh time.
Path lifetime	Number of seconds remaining in the lifetime of the reservation.
Resv refresh	Remaining time in seconds for the next Resv refresh.
Resv lifetime	Number of seconds remaining in the lifetime of the reservation.
Retry count	Number of times sanity polling periodically checks for an error condition in the FPC.
intrvl	Interval sets the time for the messages in order to control the session.
next retry in	Remaining time in seconds for the next retry.
RRO re-use as ERO	Enabling to re-use Record route as Explicit route for rsvp session.
Label Recording	Enabling to record the labels exchanged by all the peers.
FRR Admin Groups/Admin Groups	Resource affinities associated with the rsvp session.
Exclude path detail	Detailed List of the link addresses to be excluded for RSVP Bypass session.
Exclude Link	Address of the Link to be excluded for RSVP Bypass session.
Configured Path	Configured path name associated with the rsvp session.
Record route	Established rsvp path with each hop information.
Style	Reservation style associated with the rsvp session.
Traffic type	Traffic type associated with the rsvp session.
Minimum Path MTU	Path maximum transmission unit (MTU) discovery in the interface.
LSP Type	Type of ELSP signal.
CLASS	Name of the class which is associated with rsvp session.
DSCP_value	DSCP value of diff-serv class which is associated with rsvp session.
EXP_value	EXP value of diff-serv class which is associated with rsvp sess
DSTE Class Type Number	Diff-serv class type number associated with rsvp session.
Class Type name	Diff-serv class type name associated with rsvp session.
Last Recorded Error Code	The last recorded error code for the RSVP session.
Last Recorded Error Value	The last recorded error for the RSVP session.
Node where Last Recorded Error originated	Error originated node in the rsvp session.

Table 7-14: show rsvp session ingress output field

Field	Description
Trunk Type	Trunk type in the rsvp session.
Tesid	Traffic Engineering Service Instance Identifier.
Merge Point Address	Address of the node where the Bypass LSP joins with the protected LSP.

show rsvp session LSP-NAME

Use this command to display information only for sessions with a specified name.

Note: This command doesn't work for sessions with tunnel name larger than 32 characters or sessions originated from non-OcNOS solutions.

Command Syntax

```
show rsvp session LSP-NAME
show rsvp session LSP-NAME primary
show rsvp session LSP-NAME secondary
```

Parameters

primary	Use this parameter to display any primary LSP sessions
secondary	Use this parameter to display any secondary LSP sessions

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Usage

Following is a sample output from the command displaying session information about the LSP named t1.

```
#show rsvp session t1
Ingress (Primary)
192.168.0.90
  From: 192.168.0.63, LSPstate: Up, LSPname: t1
  Setup priority: 7, Hold priority: 0
  CSPF usage: Disabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  Label in: -, Label out: 17,
  Tspec rate: 0
  Tunnel Id: 1, LSP Id: 1, Ext-Tunnel Id: 192.168.0.63
  Downstream: 10.10.23.60, eth0
  Path refresh: 30 seconds (due in 34 seconds)
  Resv lifetime 157 seconds (due in 155 seconds)
  Retry Count: 0, Retry Interval: 30 seconds
  RRO re-use as ERO: Enabled
  Labels Recording: Disabled
  Admin Groups: include-any --> 0(a)
  Configured Path: p1 (in use)
  Configured Explicit Route Detail :
    10.10.23.60/32 loose
  Session Explicit Route Detail :
    10.10.23.60/32 loose
    10.10.21.90/32 loose
  Record route: <self> 10.10.23.60 10.10.21.90
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  Last Recorded Error Code: None
```



```
Last Recorded Error Value: None
#
```

Table 7-15 explains the show command output fields.

Table 7-15: show rsvp session LSP-NAME output field

Field	Description
Ingress (Primary)	Information about ingress RSVP sessions. Each session has one line of output.
From	Source (ingress switch) of the session.
LSP state	State of the LSP that is being handled by this RSVP session. It can be either Up, Dn (down), or Admin Dn. Admin Dn indicates that the LSP is being taken down gracefully.
LSPname	Name of the LSP.
Setup priority	Value of the setup priority.
Hold priority	Determines the degree to which an LSP holds onto its session reservation after the LSP has been set up successfully.
CSPF usage	CSPF usage state in the rsvp session.
LSP Protection	Protects the traffic failures.
Label in	Incoming label for this LSP.
Label out	Outgoing label for this LSP.
Tspec rate	Sender's traffic specification, which describes the sender's traffic parameters.
Fspec rate	Fspec peak rate values.
Tunnel id	Tunnel address (destination port) for the session.
LSP id	Address of the LSP in the interface.
Ext-Tunnel Id	Session address for the ext-tunnel.
Down stream	Specify the dnstream label for the bidirectional label-switched path (LSP).
Path refresh	Path messages are sent periodically to refresh path states. The refresh interval is controlled by a variable called the refresh time.
Resv lifetime	Number of seconds remaining in the lifetime of the reservation.
Retry count	Number of times sanity polling periodically checks for an error condition in the FPC.
intrvl	Interval sets the time for the messages in order to control the session.
RRO re-use as ERO	Enabling to re-use Record route as Explicit route for rsvp session.
Label Recording	Enabling to record the labels exchanged by all the peers.
Admin Groups	Resource affinities associated with the rsvp session.

Table 7-15: show rsvp session LSP-NAME output field

Field	Description
Configured Path	Configured path name associated with the rsvp session.
Configured Explicit Route Detail	Configured explicit route with each hop information.
Session Explicit Route Detail	Established explicit route with each hop information.
Record route	Established rsvp path with each hop information.
Style	Reservation style associated with the rsvp session.
Traffic type	Traffic type associated with the rsvp session.
Minimum Path MTU	Path maximum transmission unit (MTU) discovery in the interface.
Last Recorded Error Code	Recorded error code for the last time service ran.
Last Recorded Error Value	No Recorded error value for the last time service ran.

show rsvp session transit

Use this command to display session-related information for the transit or intermediate router.

Command Syntax

```
show rsvp session transit
show rsvp session transit detail
show rsvp session transit up
show rsvp session transit down
show rsvp session transit up detail
show rsvp session transit down detail
```

Parameters

up	Use this parameter to display sessions that are operational
down	Use this parameter to display sessions that are not operational
detail	Use this parameter to display detailed session-related information

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

Following are sample outputs from the command displaying detailed session information for the transit router.

```
#show rsvp session transit detail
Transit (Primary)
10.10.21.3
  From: 1.1.1.1, LSPstate: Up, LSPname: t1
  Setup priority: 5, Hold priority: 5
  LSP Protection: None
  Label in: 16, Label out: 3,
  Tspec rate: 10m, Fspec rate: 10m
  Tunnel Id: 1, LSP Id: 2, Ext-Tunnel Id: 1.1.1.1
  Downstream: 10.10.21.3, eth1 Upstream: 10.10.23.1, eth3
  Path refresh: 5 seconds (due in 6155 seconds)
  Path lifetime: 26 seconds (due in 25 seconds)
  Resv refresh: 5 seconds (due in 2533 seconds)
  Resv lifetime: 26 seconds (due in 25 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: Received Explicit Route Detail :
    10.10.23.2/32 strict
  Record route: 10.10.23.1 <self> 10.10.21.3
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type: ELSP_SIGNAL
  CLASS DSCP_value EXP_value
```

```

af43      100110      7
DSTE Class Type Number: 0, Class Type name: default
#

```

Table 7-16 explains the show command output fields.

Table 7-16: show rsvp session transit output field

Field	Description
Transit (Primary)	Transit RSVP sessions information in the interface.
From	Source (ingress switch) of the session.
LSP state	State of the LSP that is being handled by this RSVP session. It can be either Up, Dn (down), or Admin Dn. Admin Dn indicates that the LSP is being taken down gracefully.
LSP name	Name of the LSP.
Setup priority	Value of the setup priority.
Hold priority	Determines the degree to which an LSP holds onto its session reservation after the LSP has been set up successfully.
LSP Protection	Protects the traffic failures.
Label in	Incoming label for this LSP.
Label out	Outgoing label for this LSP.
Tspec rate	Sender's traffic specification, which describes the sender's traffic parameters.
Fspec rate	Fspec peak rate values.
Tunnel id	Tunnel address (destination port) for the session.
LSP id	Address of the LSP in the interface.
Ext-Tunnel Id	Session address for the ext-tunnel.
Down stream	Specify the dnstream label for the bidirectional label-switched path (LSP).
Path refresh	Path messages are sent periodically to refresh path states. The refresh interval is controlled by a variable called the refresh time.
Resv lifetime	Number of seconds remaining in the lifetime of the reservation.
RRO re-use as ERO	Enabling to re-use Record route as Explicit route for rsvp session.
Label Recording	Enabling to record the labels exchanged by all the peers.
Admin Groups	Resource affinities associated with the rsvp session.
Configured Explicit Route Detail	Configured path name associated with the rsvp session.

Table 7-16: show rsvp session transit output field

Field	Description
Record route	Recorded route for the session, taken from the record route object. Normally this value will be the same as that of explct route. Differences indicate that path rerouting has occurred, typically during fast reroute.
Style	Reservation style associated with the rsvp session.
Traffic type	Traffic type associated with the rsvp session.
Minimum Path MTU	Path maximum transmission unit (MTU) discovery in the interface.
LSP Type	Type of LSP for Diffserv services(E-LSP or L-LSP).
CLASS	Name of the class which is associated with rsvp session.
DSCP_value	DSCP value of diff-serv class which is associated with rsvp session.
EXP_value	EXP value of diff-serv class which is associated with rsvp session.
DSTE Class Type Number	Diff-serv class type number associated with rsvp session.
Class Type name	Diff-serv class type name associated with rsvp session.

show rsvp statistics

Use this command to display overall statistics of different type of RSVP control messages sent and received in a node.

Command Syntax

```
show rsvp statistics
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp statistics
PacketType      Sent      Total
                  Received
Path             627        501
PathErr           0         24
PathTear          1         27
Resv FF           30          9
Resv WF           0          0
Resv SE           646       583
Resv Err          0          0
ResvTear          0          0
ResvConf          0          0
Hello            330604     334461
Bundle            1006        866
Ack                50         14
SRefresh          34348     32424
Notify            0          0
```

show rsvp summary-refresh

Use this command to display RSVP summary refresh data.

Command Syntax

```
show rsvp summary-refresh
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp summary-refresh:
Neighbor Addr      Tunnel ID  LSP ID      Ingress      Egress
```

[Table 7-17](#) explains the show command output fields.

Table 7-17: show rsvp trunk output field

Field	Description
Neighbor Addr	Neighbor address on the primary address of the interface.
Tunnel ID	Tunnel identifier (destination port) for the RSVP session.
LSP ID	Address of the LSP in the interface.
Ingress	Information about ingress RSVP sessions.
Egress	Information about egress RSVP sessions.

show rsvp trunk

Use this command to display information for a specific trunk or for all trunks.

Command Syntax

```
show rsvp trunk
show rsvp trunk NAME
show rsvp trunk detail
```

Parameters

NAME	Enter the name of a trunk
detail	Use this parameter to display detailed information for all trunks

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp trunk
Trunk Name      Trunk ID  Type      # Sess      Egress Address(es)
T1              101      P2P       1           4.4.4.4
T2              102      P2P       2           5.5.5.5
Total trunks configured: 3.
#
```

Following is a sample output from the command using the detail parameter.

```
#show rsvp trunk detail
Trunk name: T1, tunnel-id: 101
Type: P2P
Ext-tunnel-id: 1.1.1.1/32
Egress: 4.4.4.4/32
# of LSPs in trunk: 1
Mapped-routes: none

Trunk name: T2, tunnel-id: 102
Type: P2P
Ext-tunnel-id: 1.1.1.1/32
Egress: 5.5.5.5/32
# of LSPs in trunk: 2
Mapped-routes: none
```

[Table 7-18](#) explains the show command output fields.

Table 7-18: show rsvp trunk output field

Field	Description
Trunk Name	Name of the trunk.
Trunk ID	Session address for the trunk.
Type	Trunk type in the rsvp session.
Sess	Number of sessions associated with rsvp trunk.
Egress	Information about egress RSVP sessions.
Total trunks configured	Number of configured trunk in the rsvp session.
Ext-tunnel-id	Extended Tunnel identifier (destination port) for the RSVP session.
Mapped-routes	Map the route of the interface.

show rsvp trunk multi-sec-detail

Use this command to display secondary priority details specific to a trunk or for all trunks

Command Syntax

```
show rsvp trunk multi-sec-detail
show rsvp trunk NAME multi-sec-detail
```

Parameters

NAME	Enter the name of a trunk
------	---------------------------

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
# show rsvp trunk multi-sec-detail
Ingress (Secondary-Priority1)
5.5.5.5
  From: 6.6.6.6, LSPstate: Dn, LSPname: t2-Secondary-Priority-1
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -, Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2206, Ext-Tunnel Id: 6.6.6.6
  Last Recorded Error Code: Routing Problem (24)
  Last Recorded Error Value: No route available toward destination (5)
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Secondary-Priority3)
5.5.5.5
  From: 6.6.6.6, LSPstate: Dn, LSPname: t2-Secondary-Priority-3
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -, Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2206, Ext-Tunnel Id: 6.6.6.6
  Last Recorded Error Code: Routing Problem (24)
  Last Recorded Error Value: No route available toward destination (5)
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
```

show rsvp version

Use this command to display the version of the RSVP daemon. Current RSVP version is 1.

Command Syntax

```
show rsvp version
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp version
Resource ReSerVation Protocol, version 1. rfc2205
  RSVP protocol      = Enabled
  R(refresh timer)   = 30 seconds
  K(keep multiplier) = 3
  Preemption         = Normal
#
```

[Table 7-19](#) explains the show command output fields.

Table 7-19: show rsvp version output field

Field	Description
Resource Reservation Protocol	RSVP software version.
RSVP protocol	Status of RSVP.
R (refresh timer)	Configured time interval used to generate periodic RSVP messages.
K (keep multiplier)	Number of RSVP messages that can be lost before an RSVP state is declared stale.
Preemption	Currently configured preemption capability.

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