ipinfusion™

ZebOS-XP®
Network Platform

Version 1.4
Extended Performance

Multi-Protocol Label Switching
Configuration Guide

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IP Infusion Inc.
3965 Freedom Circle, Suite 200
Santa Clara, CA 95054
+1 408-400-1900
http://www.ipinfusion.com/

For support, questions, or comments via E-mail, contact:
support@ipinfusion.com

Contents

Preface

This guide describes how to configure Multi-Protocol Label Switching (MPLS) in ZebOS-XP.

Audience

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

Conventions

Table P-1 shows the conventions used in this guide.

Table P-1: Conventions

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

Contents

This document contains these chapters and appendices:

- Chapter 14, *DiffServ-TE Configuration*
- Chapter 15, *Pseudowire Status*
- Chapter 16, *PW Redundancy Configuration*
- Chapter 17, *Multi-Segment Pseudowire Configuration*
- Chapter 18, *SAToP Configuration*
- Chapter 19, *MPLS Non Stop Forwarding*
- Chapter 19, *MPLS-TP Protocols*
- Chapter 20, *MPLS-TP Tunnel Architecture*
- Chapter 21, *MPLS-TP Tunnel Configurations*
- Chapter 22, *MPLS-TP Tunnel Bandwidth*
- Chapter 23, *MPLS-TP IPv4 Map Route*
- Chapter 24, *MPLS-TP Layer 2 Virtual Circuit*
- Chapter 25, *MPLS-TP MEG Configuration*
- Chapter 26, *MPLS-TP LSP Ping and Traceroute*
- Chapter 27, *MPLS-TP BFD for LSPs*
- Chapter 28, *MPLS-TP Lock Instruct and Loopback*
- Chapter 29, *MPLS-TP Loss and Delay Measurement*
- Chapter 30, *MPLS-TP Fault Management Configuration*
- Chapter 31, *MPLS-TP Linear Protection Switching*
- Chapter 32, *MPLS-TP Ring Protection Switching*
- Chapter 33, *MPLS-TP Y.1731 OAM Configuration*

Related Documents

Except where otherwise noted, use this guide with the *Multi-Protocol Label Switching Command Reference* for details about the commands used in the configurations.

Also use this guide with these command references for details about other commands used in the configurations.

- *Label Distribution Protocol Command Reference*
- *RSVP-TE Command Reference*
- *Border Gateway Protocol Command Reference*
- *Open Shortest Path First Command Reference*
- *Intermediate System-to-Intermediate System Command Reference*
- *Network Services Module Command Reference*

Note: All ZebOS-XP technical manuals are available to licensed customers at http://www.ipinfusion.com/support/document_list.

Chapter Organization

The chapters in this guide 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

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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. TheLDP 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, ZebOS-XP LDP assigns labels to every destination address and destination prefix provided by ZebOS-XP. 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 ZebOS-XP 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 ZebOS-XP 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 incriminated 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 and enable-ldp ipv6` command are used to enable LDP for IPv4 or LDP for IPv6, on a specified interface, as follows:

- `enable-ldp ipv4` enables only IPv4 on the interface
- `enable-ldp ipv6` enables only IPv6 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.

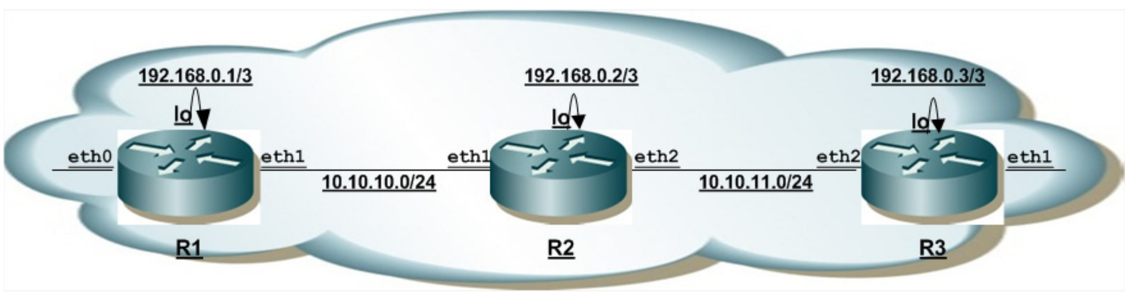


Figure 1-1: Basic LDP Topology

R1

NSM

`#configure terminal`	Enter configure mode.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#label-switching`	Enable label switching on interface `eth1`.
`(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`	Set the IP address of the loopback interface to `192.168.0.1/32`.

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)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface eth1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on eth1.
(config-if)#exit	Exit interface mode.

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.

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	Set the IP address of the loopback interface to 192.168.0.2/32.
(config-if)#exit	Exit interface mode.
(config)#interface eth1	Specify the interface (eth1) to be configured.
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Specify the interface (eth2) to be configured.
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#exit	Exit interface mode.

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 eth1`	Specify the interface `(eth1)` to be configured.
`(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)#enable-ldp ipv4`	Enable LDP on a specified interface (`eth2)`.
`(config-if)#exit`	Exit interface mode.

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.

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`	Set the IP address of the loopback interface to `192.168.0.3/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Specify the interface `(eth2)` to be configured.
`(config-if)#label-switching`	Enable label switching on interface `eth2`.
`(config-if)#exit`	Exit interface mode.

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)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface eth2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on eth2.
(config-if)#exit	Exit interface mode.

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.

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.

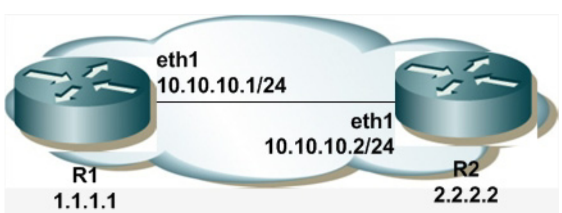


Figure 1-2: Topology for Direct Session MD5

R1

#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)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface eth1	Specify the interface (eth1) to be configured.
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#enable-ldp ipv4	Enable LDP on interface eth1.
(config-if)#exit	Exit interface mode.

R2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode.
(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 eth1	Specify the interface (eth1) to be configured.
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#enable-ldp ipv4	Enable LDP on interface eth1.
(config-if)#exit	Exit interface mode.

Configure LDP MD5 for Targeted LDP Session

In this example, MD5 authentication is configured for the targeted LDP session established between R1 and R3.

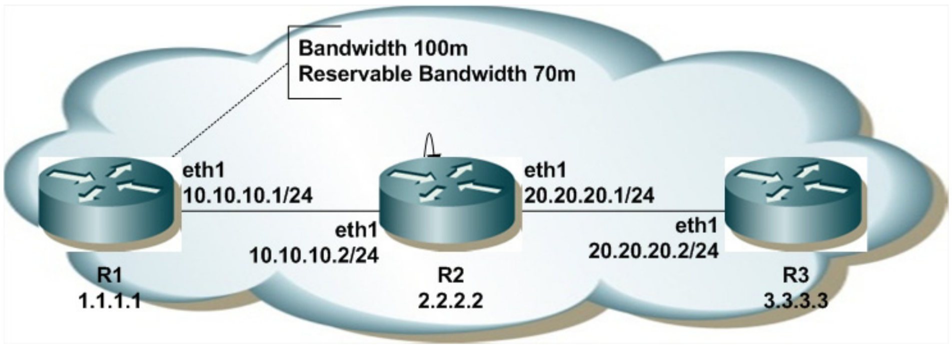


Figure 1-3: Topology for Targeted Session MD5

R1

`#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)#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 eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#label-switching`	Enable label switching on interface `eth1`.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `eth1`.
`(config-if)#exit`	Exit interface mode.

R2

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter `Router` mode to enable LDP.
`(config-router)#exit`	Exit the `Router` mode and return to the `Configure` mode.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#label-switching`	Enable label switching on interface `eth1`.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `eth1`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Specify the interface `(eth2)` to be configured.
`(config-if)#label-switching`	Enable label switching on interface `eth2`.

(config-if)#enable-ldp ipv4	Enable LDP on interface eth2.
(config-if)#exit	Exit interface mode.

R3

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure the targeted peer IP address (R1 loopback address).
(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 eth1	Specify the interface (eth1) to be configured.
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#enable-ldp ipv4	Enable LDP on interface eth1.
(config-if)#exit	Exit interface mode.

Removing MD5 Authentication for LDP Session

This example shows removing the MD5 authentication configuration from an LDP session.

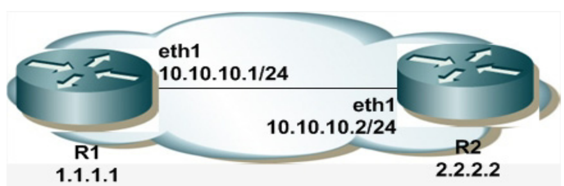


Figure 1-4: LDP Session Topology

R1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode.
(config-router)#no neighbor 10.10.10.2 auth md5 password 0 pwd1	Remove MD5 authentication for the neighbor, 10.10.10.2.
(config-router)#exit	Exit the Router mode and return to the Configure mode.

R2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode.
(config-router)#no neighbor 10.10.10.1 auth md5 password 0 pwd1	Remove MD5 authentication for the neighbor, 10.10.10.1.
(config-router)#exit	Exit the Router mode and return to the Configure mode.

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]
--------------------------------------------
#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: 300000]
  Primary FTNs       : 300000       [UP: 300000]
  Secondary FTNs     : 0            [UP: 0]
---------------------------------------------
---------------------------------------------
  Num IPV6 FTNs      : 300000     [UP: 300000]
  Primary IPV6 FTNs : 300000     [UP: 300000]
  Secondary IPV6 FTNs : 0        [UP: 0]
---------------------------------------------

#show mpls ilm-table count
------------------------------------------------
Num ILMs         : 300000          [UP: 300000]
  Swap Entries   : 300000          [UP: 300000]
  Pop Entries    : 0               [UP: 0]
  VC Pop Entries : 0               [UP: 0]
------------------------------------------------
```


CHAPTER 2 LDP and RSVP-TE Graceful Restart

This chapter contains configurations for Label Distribution Protocol (LDP) Graceful Restart. To see details about the commands used in this example, or to see output of the Validation commands, refer to the `ZebOS-XP Network Platform Label Distribution Command Reference`. Common commands are defined in the `ZebOS-XP Network Platform Network Services Manager Command Reference`. For commands used to enter each mode see the `Command Modes` section in Preface on page xi.

Overview

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

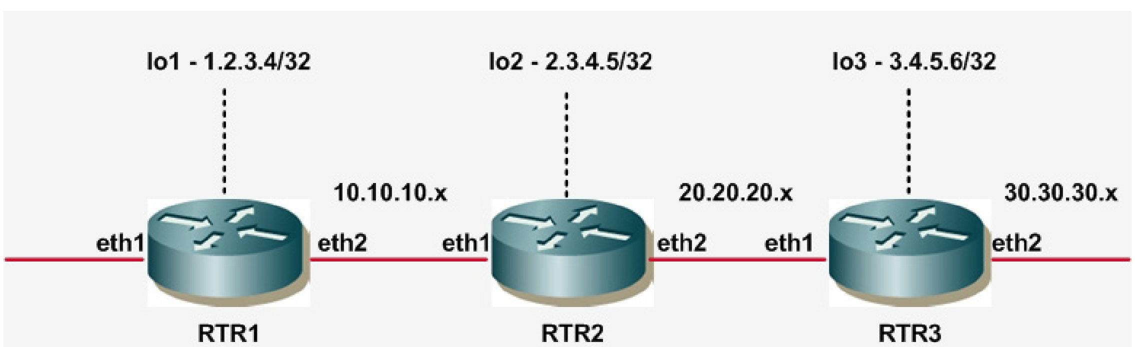


Figure 2-1: Topology

RTR1

`#configure terminal`	Enter Configure mode.
`(config)#interface eth1`	Enter Interface mode for eth1.
`(config-if)#ip add 10.10.10.51/24`	Assign IP address.

`(config-if)#exi`	Exit interface mode and return to configure mode.
`(config)#interface lo`	Enter interface mode for lo.
`(config-if)#exit`	Exit interface mode and return to configure mode.
`(config)#router ospf 100`	Enter Router OSPF mode.
`(config-router)#network 1.2.3.4/32 area 0`	Configure OSPF network address in area 0.
`(config-router)#network 10.10.10.0/24 area 0`	Configure OSPF network address in area 0.
`(config-router)#exit`	Exit Router OSPF mode and return to configure mode.
`(config)#router ldp`	Enter Router LDP mode.
`(config-router)#graceful-restart disable`	Disable LDP graceful restart.
`(config-router)#graceful-restart enable`	Enable LDP graceful restart.
`(config-router)#graceful-restart timers max-recovery 120`	Configure maximum LDP graceful-restart recovery timer.
`(config-router)#graceful-restart timers neighbor-liveness 80`	Configure LDP graceful-restart neighbor- liveness timer.
`(config-router)#exit`	Exit Router LDP mode and return to configure mode.
`(config)#interface eth1`	Enter Interface mode for eth1.
`(config-if)#label-switching`	Enable label-switching on the interface connected to S-PE.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface connected to S-PE.
`(config-if)#exit`	Exit interface mode.
`(config)#exit`	Exit configure mode.

RTR2

`#configure terminal`	Enter Configure mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#ip add 10.10.10.53/24`	Assign IP address.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#ip add 20.20.20.53/24`	Assign IP address.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Enter Router OSPF mode.
`(config-router)#network 2.3.4.5/32 a 0`	Configure OSPF network for area 0.
`(config-router)#network 10.10.10.0/24 a 0`	Configure OSPF network for area 0.
`(config-router)#network 20.20.20.0/24 a 0`	Configure OSPF.
`(config-router)#exit`	Exit Router OSPF mode and return to Configure mode.
`(config)#router ldp`	Enter Router LDP mode.
`(config-router)#graceful-restart enable`	Enable LDP graceful restart.
`(config-router)#graceful-restart disable`	Disable LDP graceful restart.
`(config-router)#graceful-restart timers max-recovery 120`	Configure maximum LDP max-recovery timer.

`(config-router)#graceful-restart timers neighbor-liveness 80`	Configure LDP graceful-restart neighbor- liveness timer.
`(config-router)#exit`	Exit Router LDP mode and return to Configure mode.
`(config)#interface eth1`	Enter interface mode.
`(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 eth2`	Enter interface mode.
`(config-if)#label-switching`	Enable label-switching on the interface.
`(config-if)#enable-ldp ipv4`	Enable LDP on the interface.
`(config-if)#end`	Exit interface mode and configure mode.
`#restart ldp graceful`	Restart LDP gracefully on DUT i.e. RTR2

RTR3

`#configure terminal`	Enter Configure mode.
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#ip add 20.20.20.54/24`	Assign IP address.
`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)#interface lo`	Enter Interface mode for loopback interface.
`(config-if)#ip add 3.4.5.6/32`	Assign IP address.
`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)#router ospf 100`	Enter Router OSPF mode.
`(config-router)#network 3.4.5.6/32 area 0`	Configure OSPF network for area 0.
`(config-router)#network 20.20.20.0/24 area 0`	Configure OSPF network for area 0.
`(config-router)#exit`	Exit Router OSPF mode and return to Configure mode.
`(config)#router ldp`	Enter Router LDP mode.
`(config-router)#graceful-restart disable`	Disable LDP graceful restart.
`(config-router)#graceful-restart enable`	Enable LDP graceful restart.
`(config-router)#graceful-restart timers max-recovery 120`	Configure maximum LDP graceful recovery timer.
`(config-router)#graceful-restart timers neighbor-liveness 80`	Configure LDP graceful-restart neighbor- liveness timer.
`(config-router)#exit`	Exit Router LDP mode and return to Configure mode.
`(config)#interface eth2`	Enter Interface mode for eth1.
`(config-if)#label-switching`	Enable label-switching on interface.
`(config-if)#enable-ldp ipv4`	Enable LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#exit`	Exit configure mode.

Validation

On RTR2 (DUT), save the configuration:

```
#wr
Building configuration...
[OK]
#
```

Display Graceful-Restart Capability

show ldp graceful-restart, show nsm forwarding-timer, show mpls forwarding-table, show mpls ilm-table, show cal

```
RTR2#show ldp graceful-restart

Peer IP Address           IF Name    Restart    My State     Timer Value
1.2.3.4                   eth1       Capable    OPERATIONAL  0(No Timers
Running)
3.4.5.6                   eth2       Capable    OPERATIONAL  0(No Timers
Running)

#show nsm forwarding-timer
==================================================================== Protocol-
Name GR-StateTime Remaining (sec)Disconnected-time
LDPACTIVE02015/04/26 10:52:15
====================================================================

#show ru router ldp
====================================================================
router ldp
graceful-restart enable
graceful-restart timers neighbor-liveness 120 graceful-restart timers max-
recovery 80
====================================================================
```

Start LDP Graceful on Router 2

Use the commands below to start LDP graceful on a router.

```
#restart ldp graceful
ZebOS-XP#show process
====================================================================

  PID NAMETIME FD
1 nsm16:50:25 13
4 ospfd16:50:28 8
7 bgpd16:50:28 10
31 vlogd16:50:28 9
====================================================================
ZebOS-XP#show ldp session
ZebOS-XP#show nsm forwarding-timer
==================================================================== Protocol-
Name GR-State Time Remaining (sec)Disconnected-time
LDP          ACTIVE      110      2015/01/01 06:06:49
```

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

#show ldp graceful-restart
=====================================================================
RTR2#show mpls forwarding-table
=====================================================================
Codes: > - selected FTN, p - stale FTN, B - BGP FTN, K - CLI FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, T - MPLS-TP Map 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> p   1.2.3.4/32        1        0          Yes   LSP_DEFAULT    3
eth1        p 10.10.10.51
L> p   3.4.5.6/32        2        0          Yes   LSP_DEFAULT    3
eth2        p 20.20.20.54
=====================================================================
RTR2#show mpls ilm-table
Codes: > - 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
  >  p1.2.3.4/32         1           53120        3          eth2     eth1
p 10.10.10.51         LSP_DEFAULT
  >  p3.4.5.6/32         2           53121        3          eth1     eth2
p 20.20.20.54         LSP_DEFAULT
=====================================================================
ZebOS-XPsbin]#./ldpd –d (Restart LDP manually)

ZebOS-XP#show process
===================================================================== PID NAME
TIME FD
1 nsm17:00:46 13
4 ospfd17:00:49 8
7 bgpd17:00:49 10
8 ldpd00:00:59 7
31 vlogd17:00:49 9
===================================================================== RTR2#show
ldp session
====================================================================
Peer IP Address           IF Name    My Role    State      KeepAlive
1.2.3.4                   eth1       Active    OPERATIONAL   30
3.4.5.6                   eth2       Passive   OPERATIONAL   30
=====================================================================
RTR2#show mpls forwarding-table
=====================================================================
Codes: > - selected FTN, p - stale FTN, B - BGP FTN, K - CLI FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, T - MPLS-TP Map 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>     1.2.3.4/32        1        0          Yes   LSP_DEFAULT    3
eth1          10.10.10.51
L>     3.4.5.6/32        2        0          Yes   LSP_DEFAULT    3
eth2          20.20.20.54
=====================================================================
```

```
RTR2#show mpls ilm-table
===================================================================
Codes: > - 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
  >   1.2.3.4/32          1          53120       3          eth2     eth1
10.10.10.51         LSP_DEFAULT
  >   3.4.5.6/32          2          53121       3          eth1     eth2
20.20.20.54         LSP_DEFAULT
==================================================================
RTR2#show ldp graceful-restart
==================================================================
Peer IP Address           IF Name    Restart    My State     Timer Value
1.2.3.4                   eth1       Capable    RESTARTING   90(Recovery Time)
3.4.5.6                   eth2       Capable    RESTARTING   90(Recovery Time)
===================================================================
RTR2#show nsm forwarding-timer
===================================================================

Protocol-Name  GR-State  Time Remaining (sec)   Disconnected-time
     LDP        ACTIVE           0            2015/01/01 06:06:49
```

Neighboring LSR to RTR1

The commands in this section display graceful restart information about the neighboring LSR to RTR1.

Router Restarted Gracefully

```
RTR1#show ldp graceful-restart
==================================================================
Peer IP Address     IF Name    Restart    My State     Timer Value
2.3.4.5             eth1      Capable     HELPER_MODE  115(Re-connect Time)
=================================================================== RTR1#show
mpls forwarding-table
=================================================================== Codes: > -
selected FTN, p - stale FTN, B - BGP FTN, K - CLI FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, T - MPLS-TP Map 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> p   2.3.4.5/32        1        0          Yes   LSP_DEFAULT    3
eth1        p 10.10.10.53
L> p   3.4.5.6/32        3        0          Yes   LSP_DEFAULT    53121
eth1        p 10.10.10.53
L> p   20.20.20.0/24      2        0          Yes   LSP_DEFAULT    3
eth1        p 10.10.10.53
===================================================================
```

After Completion of LDP GR on RTR1

```
#show ldp graceful-restart
============================================================
Peer IP Address    IF Name    Restart    My State     Timer Value
2.3.4.5            eth1       Capable    HELPER_MODE  115(Recovery Time)
============================================================
```


After Completion of GR on RTR2

```
#show ldp graceful-restart
===================================================================
Peer IP Address    IF Name    Restart    My State     Timer Value
1.2.3.4            eth1       Capable    OPERATIONAL  0(No Timers Running)
3.4.5.6            eth2       Capable    OPERATIONAL  0(No Timers Running)
===================================================================
```

Display NSM Forwarding Timers

Use these commands to display data about the NSM forwarding timer before, during and after LDP graceful restart.

Before LDP Graceful Restart

```
#show nsm forwarding-timer
===================================================================
Protocol-Name GR-State Time Remaining (sec)    Disconnected-time
===================================================================
```

During LDP GR

The examples below show NSM forwarding timer Time Remaining as it is reduced while LDP is restarting gracefully.

```
#show nsm forwarding-timer
===================================================================
Protocol-Name GR-State Time Remaining (sec)    Disconnected-time
     LDP        ACTIVE           119           2010/04/26 12:22:13
===================================================================

#show nsm forwarding-timer
===================================================================
Protocol-Name GR-State Time Remaining (sec)    Disconnected-time
     LDP        ACTIVE           115           2010/04/26 12:22:13
===================================================================

#show nsm forwarding-timer
===================================================================
Protocol-Name GR-State Time Remaining (sec)    Disconnected-time
     LDP        ACTIVE           114           2010/04/26 12:22:13
===================================================================
```

After Completion of LDP Graceful Restart

After LDP has restarted gracefully, the Time Remaining for the process is now zero (0) seconds.

```
#show nsm forwarding-timer
===================================================================
Protocol-Name  GR-State  Time Remaining (sec)   Disconnected-time
     LDP        ACTIVE            0            2010/04/26 12:22:13

MPLS-PC3#
```

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

Display Graceful Restart RecoveryTimer

```
RTTR2#show ldp graceful-restart
===================================================================
Peer IP Address    IF Name    Restart    My State     Timer Value
1.2.3.4            eth1       Capable    RESTARTING   116(Recovery Time)
3.4.5.6            eth2       Capable    RESTARTING   116(Recovery Time)
===================================================================

#show ldp graceful-restart
===================================================================
Peer IP Address    IF Name    Restart    My State     Timer Value
1.2.3.4            eth1       Capable    RESTARTING   88(Recovery Time)
3.4.5.6            eth2       Capable    RESTARTING   88(Recovery Time)
===================================================================
```

RSVP Graceful Restart

RSVP graceful restart allows RSVP TE enabled nodes to recover gracefully after a node failure in the network, so that the RSVP state is restored as quickly as possible. The node failure may be completely transparent to other nodes in the network. RSVP graceful restart depends on RSVP hello messages to detect when a neighbor went down. Hello messages include Hello Request or Hello Acknowledgment (ACK) objects between two neighbors. A node hello is transmitted when graceful restart is globally configured and the first LSP to the neighbor is created.

Topology

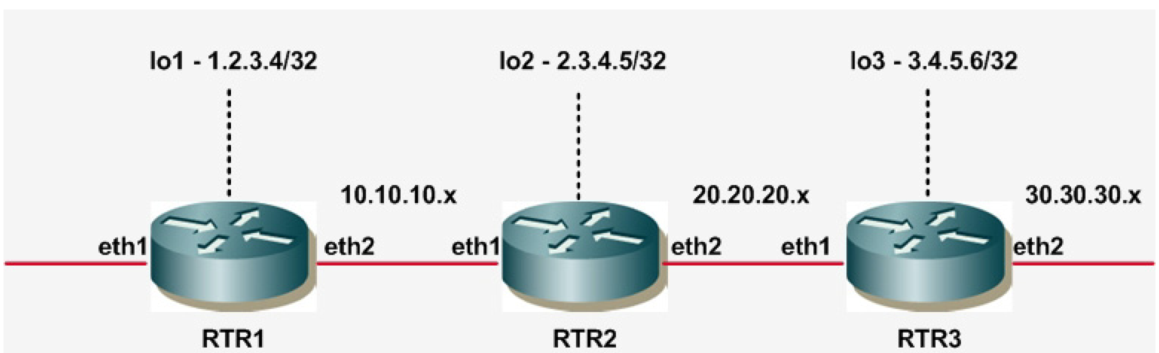


Figure 2-2: RSVP Graceful Restart Topology

RTR1

`#configure terminal`	Enter configure mode.
`(config)#interface eth1`	Specify the interface (eth1) to be configured and enter the Interface mode
`(config-if)#ip address 10.10.10.51/24`	Assign IP address to the interface

(config-if)#exit	Exit interface mode
(config)#interface lo	Enter Interface mode for loopback interface.
(config-if)#ip address 1.2.3.4/32	Assign IP address to the interface
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Enter Router OSPF mode.
(config-router)#network 1.2.3.4/32 area 0	Configure OSPF network address in area 0.
(config-router)#network 10.10.10.0/24 area 0	Configure OSPF network address in area 0.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#router rsvp	Enter Router RSVP mode.
(config-router)#graceful-restart enable	Enable RSVP graceful restart.
(config-router)#graceful-restart restart-time 120000	Configure maximum RSVP graceful-restart recovery timer.
(config-router)#graceful-restart recovery-time 120000	Configure RSVP graceful-restart neighbor- liveness timer.
(config-router)#no-php	Disabling Penultimate Hop Popping.
(config-router)#neighbor 10.10.10.53	Configuring RSVP neighbor.
(config-router)#exit	Exit Router RSVP mode and return to Configure mode.
(config)#interface eth1	Enter Interface mode for eth1.
(config-if)#label-switching	Enable label-switching on the interface connected to S-PE.
(config-if)#enable-rsvp	Enable RSVP on interface connected to S-PE.
(config-if)#rsvp-trunk T1	Create an RSVP trunk T1.
(config-if)#to 3.4.5.6	Configuring the destination address of the trunk.
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#exit	Exit Configure mode.

RTR2

#configure terminal	Enter configure mode.
(config)#interface eth1	Specify the interface (eth1) to be configured and enter the Interface mode
(config-if)#ip address 10.10.10.53/24	Assign IP address to the interface
(config-if)#exit	Exit interface mode
(config)#interface eth2	Enter Interface mode for eth2.
(config-if)#ip add 20.20.20.53/24	Assign IP address.
(config)#interface lo	Enter Interface mode for loopback interface.
(config-if)#ip add 2.3.4.5/32	Assign IP address.
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#router ospf 100	Enter Router OSPF mode.
(config-router)#network 2.3.4.5/32 area 0	Configure OSPF network for area 0.
(config-router)#network 10.10.10.0/24 area 0	Configure OSPF network for area 0.
(config-router)#network 20.20.20.0/24 area 0	Configure OSPF.

(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#router rsvp	Enter Router RSVP mode.
(config-router)#graceful-restart enable	Enable RSVP graceful restart.
(config-router)# graceful-restart restart-time 120000	Configure maximum RSVP max-recovery timer.
(config-router)# graceful-restart recovery-time 120000	Configure RSVP graceful-restart neighbor- liveness timer.
(config-router)#no-php	Disabling Penultimate Hop Popping.
(config-router)#neighbor 10.10.10.51	Configuring RSVP neighbor.
(config-router)#neighbor 20.20.20.54	Configuring RSVP neighbor.
(config-router)#exit	Exit Router RSVP mode and return to Configure mode.
(config)#interface eth1	Enter Interface mode for eth1.
(config-if)#label-switching	Enable label-switching on the interface.
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface eth2	Enter Interface mode for eth2.
(config-if)#label-switching	Enable label-switching on the interface.
(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#end	Exit Interface mode and Configure mode and return to Exec.

RTR3

#configure terminal	Enter configure mode.
(config)#interface eth1	Specify the interface (eth1) to be configured and enter the Interface mode
(config-if)#ip address 20.20.20.54/24	Assign IP address to the interface
(config-if)#exit	Exit interface mode
(config)#interface lo	Enter Interface mode for loopback interface.
(config-if)#ip add 3.4.5.6/32	Assign IP address.
(config-if)#exit	Exit Interface mode and return to configure mode.
(config)#router ospf 100	Enter router OSPF mode.
(config-router)#network 3.4.5.6/32 area 0	Configure OSPF network for area 0.
(config-router)#network 20.20.20.0/24 area 0	Configure OSPF network for area 0.
(config-router)#exit	Exit router OSPF mode and return to configure mode.
(config)#router rsvp	Enter Router RSVP mode.
(config-router)#graceful-restart enable	Enable RSVP graceful restart.
(config-router)# graceful-restart restart-time 120000	Configure maximum RSVP max-recovery timer.
(config-router)# graceful-restart recovery-time 120000	Configure RSVP graceful-restart neighbor- liveness timer.
(config-router)# no-php	Disabling Penultimate Hop Popping.
(config-router)#neighbor 20.20.20.53	Configuring RSVP neighbor.

`(config-router)#exit`	Exit Router RSVP mode and return to configure mode.
`(config)#interface eth2`	Enter Interface mode for eth2.
`(config-if)#label-switching`	Enable label-switching on interface.
`(config-if)#enable-rsvp`	Enable RSVP on the interface.
`(config-if)#exit`	Exit Interface mode and return to configure mode.
`(config)#exit`	Exit configure mode.

Note: With Diffserv enabled (default), a build diffserv configuration is required for all devices (refer to the ZebOS-XP RSVP-TE Command Reference guide). The following is the minimum required configuration:

```
(config)#mpls class-type ct0 default
(config)#mpls te-class te0 default 0
(config)#mpls te-class te7 default 7
```

Validation Commands

Start RSVP Graceful on a Router 1

Before RSVP graceful restart on Router 1

```
RTR1#show rsvp session
Ingress RSVP:
To               From             State  Pri  Rt  Style  Labelin  Labelout  LSPName
DSType
3.4.5.6          1.2.3.4          Up     Yes   1   1 SE        -   52480     T1
DEFAULT
Total 1 displayed, Up 1, Down 0.

RTR1#show mpls forwarding-table
Codes: > - selected FTN, p - stale FTN, B - BGP FTN, K - CLI FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, T - MPLS-TP Map 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
R>      3.4.5.6/32          1               5001        Yes   LSP_DEFAULT
52480        eth1          10.10.10.53

RTR1#show rsvp graceful-restart
Graceful Restart: Enabled
Advertised Restart Time: 120000 msec
Advertised Recovery Time: 120000 msec
Sending Recovery Time: No

  Remote addr: 10.10.10.53           Local addr: 10.10.10.51
  Nbr State: Normal, Type: Graceful Restart
  Nbr Hello State: Up
  LSPs protecting: 1
  Restart Time: 120000 msec, Recovery Time: 0 msec
  Rest of Restat Time: 0 msec, Rest of Recovery Time: 0 msec
```

Use the commands below to start RSVP gracefully on a router.

```
RTR1#restart rsvp graceful
```

```
RTR1#show mpls forwarding-table
Codes: > - selected FTN, p - stale FTN, B - BGP FTN, K - CLI FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, T - MPLS-TP Map 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
R> p    3.4.5.6/32        1       5001       Yes   LSP_DEFAULT    52480
eth1        p 10.10.10.53

RTR1#show nsm forwarding-timer

Protocol-Name  GR-State  Time Remaining (sec)   Disconnected-time
    RSVP        ACTIVE          103          1970/01/02 05:06:27
RTR1#./rsvpd –d (Restart RSVP manually)

RTR1#show rsvp graceful-restart
Graceful Restart: Enabled
Advertised Restart Time: 120000 msec
Advertised Recovery Time: 120000 msec
Sending Recovery Time: Yes

  Remote addr: 10.10.10.53           Local addr: 10.10.10.51
  Nbr State: Normal, Type: Graceful Restart
  Nbr Hello State: Up
  LSPs protecting: 1
  Restart Time: 120000 msec, Recovery Time: 0 msec
  Rest of Restat Time: 0 msec, Rest of Recovery Time: 48884 msec

RTR1#show rsvp session
Ingress RSVP:
To             From            State Pri Rt Style Labelin Labelout LSPName
DSType
3.4.5.6         1.2.3.4         Up    Yes  1  1 SE       -   52480 T1
DEFAULT
Total 1 displayed, Up 1, Down 0.

RTR1#show mpls forwarding-table
Codes: > - selected FTN, p - stale FTN, B - BGP FTN, K - CLI FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, T - MPLS-TP Map 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
R>     3.4.5.6/32        1       5001       Yes   LSP_DEFAULT    52480
eth1          10.10.10.53
```

Start RSVP Graceful on a Router 2

Before RSVP graceful restart on Router 2.

```
RTR2#show rsvp session
Transit RSVP:
To             From            State Pri Rt Style Labelin Labelout LSPName
DSType
3.4.5.6         1.2.3.4         Up    Yes  1  1 SE   52480   53760 T1
ELSP_CON
```



```
Total 1 displayed, Up 1, Down 0.

RTR2#show mpls ilm-table
Codes: > - 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
  >   3.4.5.6/32         5           52480       53760      eth1     eth2
20.20.20.54                    ELSP_CONFIG

RTR2#show rsvp graceful-restart
Graceful Restart: Enabled
Advertised Restart Time: 120000 msec
Advertised Recovery Time: 120000 msec
Sending Recovery Time: No

  Remote addr: 10.10.10.51           Local addr: 10.10.10.53
  Nbr State: Normal, Type: Graceful Restart
  Nbr Hello State: Up
  LSPs protecting: 1
  Restart Time: 120000 msec, Recovery Time: 0 msec
  Rest of Restat Time: 0 msec, Rest of Recovery Time: 0 msec

  Remote addr: 20.20.20.54           Local addr: 20.20.20.53
  Nbr State: Normal, Type: Graceful Restart
  Nbr Hello State: Up
  LSPs protecting: 1
  Restart Time: 180000 msec, Recovery Time: 0 msec
  Rest of Restat Time: 0 msec, Rest of Recovery Time: 0 msec

Use the commands below to start RSVP gracefully on a router.
RTR2#restart rsvp graceful
RTR2#show mpls ilm-table
Codes: > - 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
  >  p3.4.5.6/32         5           52480       53760      eth1     eth2
p 20.20.20.54                    ELSP_CONFIG

RTR2#./rsvpd –d (Restart RSVP manually)

RTR2#show rsvp graceful-restart
Graceful Restart: Enabled
Advertised Restart Time: 120000 msec
Advertised Recovery Time: 120000 msec
Sending Recovery Time: Yes

  Remote addr: 10.10.10.51           Local addr: 10.10.10.53
  Nbr State: Normal, Type: Graceful Restart
  Nbr Hello State: Up
  LSPs protecting: 1
  Restart Time: 120000 msec, Recovery Time: 0 msec
  Rest of Restat Time: 0 msec, Rest of Recovery Time: 42943 msec

  Remote addr: 20.20.20.54           Local addr: 20.20.20.53
  Nbr State: Normal, Type: Graceful Restart
```



```
  Nbr Hello State: Up
  LSPs protecting: 1
  Restart Time: 180000 msec, Recovery Time: 0 msec
  Rest of Restat Time: 0 msec, Rest of Recovery Time: 42943 msec


RTR2#show rsvp session
Transit RSVP:
To              From            State Pri Rt Style Labelin Labelout LSPName
DSType
3.4.5.6          1.2.3.4         Up    Yes  1  1 SE   52480   53760 T1
ELSP_CON
Total 1 displayed, Up 1, Down 0.

RTR2#show mpls ilm-table
Codes: > - 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
  >   3.4.5.6/32         5          52480       53760      eth1     eth2
20.20.20.54                    ELSP_CONFIG
```

Start RSVP Graceful on a Router 3

Before RSVP graceful restart on Router 3.

```
RTR3#show rsvp session
Egress RSVP:
To              From            State Pri Rt Style Labelin Labelout LSPName
DSType
3.4.5.6         1.2.3.4         Up    Yes  1  1 SE   53760        - T1
ELSP_CON
Total 1 displayed, Up 1, Down 0.

RTR3#show mpls ilm-table
Codes: > - 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
  >   3.4.5.6/32         2          53760       N/A        eth2     N/A
127.0.0.1                      ELSP_CONFIG
RTR3#show rsvp graceful-restart
Graceful Restart: Enabled
Advertised Restart Time: 180000 msec
Advertised Recovery Time: 360000 msec
Sending Recovery Time: No

  Remote addr: 20.20.20.53           Local addr: 20.20.20.54
  Nbr State: Normal, Type: Graceful Restart
  Nbr Hello State: Up
  LSPs protecting: 1
  Restart Time: 120000 msec, Recovery Time: 0 msec
  Rest of Restat Time: 0 msec, Rest of Recovery Time: 0 msec
```

Use the commands below to start RSVP gracefully on a router.

```
RTR3#restart rsvp graceful

RTR3#show mpls ilm-table
Codes: > - 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
  >  p3.4.5.6/32         2           53760        N/A        eth2     N/A
p 127.0.0.1                     ELSP_CONFIG

RTR3#show nsm forwarding-timer

Protocol-Name  GR-State  Time Remaining (sec)   Disconnected-time
    RSVP        ACTIVE           174           1970/01/03 07:06:31
RTR3#

RTR3#./rsvpd –d (Restart RSVP manually)

RTR3#show mpls ilm-table
Codes: > - 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
  >   3.4.5.6/32         2          53760        N/A        eth2     N/A
127.0.0.1                     ELSP_CONFIG
RTR3#show rsvp graceful-restart
Graceful Restart: Enabled
Advertised Restart Time: 180000 msec
Advertised Recovery Time: 360000 msec
Sending Recovery Time: Yes

  Remote addr: 20.20.20.53           Local addr: 20.20.20.54
  Nbr State: Normal, Type: Graceful Restart
  Nbr Hello State: Up
  LSPs protecting: 1
  Restart Time: 120000 msec, Recovery Time: 0 msec
  Rest of Restat Time: 0 msec, Rest of Recovery Time: 346255 msec
RTR3#shp
RTR3#show rsvp session
Egress RSVP:
To             From           State Pri Rt Style Labelin Labelout LSPName
DSType
3.4.5.6        1.2.3.4         Up    Yes  1  1 SE   53760        - T1
ELSP_CON
Total 1 displayed, Up 1, Down 0.
```

CHAPTER 3 MPLS LDP-IGP Synchronization

This chapter contains configurations for Label Distribution Protocol (LDP) IGP Synch Restart.

For details about the commands, see the *Label Distribution Protocol, Open Shortest Path First,* and *Intermediate System-to-Intermediate System* command references.

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. Labelled 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 and OSPF. 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 be also be running LDP.

Topology

The sample topology diagram is applicable to all configurations in this chapter.

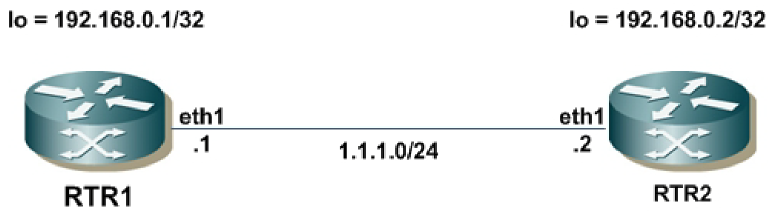


Figure 3-1: Sample Topology for LDP-IGP Synchronization

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.

RTR1

Before configuring LDP-IGP synchronization, the NSM, OSPF and LDP configurations must be completed. The tables below contain examples of how this is done.

NSM

`#configuration terminal`	Enter configuration mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#ip address 1.1.1.1/24`	Configure IPv4 address for eth1.
`(config-if)#label-switching`	Enable label switching on interface eth1.
`(config-if)#exit`	Exit the Interface mode and return to the Configure mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 192.168.0.1/32`	Set the IP address of the loopback interface to 192.168.0.1/32.

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 1.1.1.0/24 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

LDP

`(config)#router ldp`	Enter the 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 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 the Router mode and return to the Configure mode.
(config)#interface eth1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on eth1.
(config-if)#exit	Exit interface mode.

RTR2

Before configuring LDP-IGP synchronization, the NSM, OSPF and LDP configurations must be completed. The tables below contain examples of how this is done.

NSM

#configuration terminal	Enter configuration mode.
(config)#interface eth1	Enter interface mode.
(config-if)#ip address 1.1.1.2/24	Configure IPv4 address for eth1.
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#exit	Exit the Interface mode and return to the Configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 192.168.0.2/32	Set the IP address of the loopback interface to 192.168.0.2/32.

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 1.1.1.0/24 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

LDP

(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 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 eth1	Enter interface mode.

`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on eth1.
`(config-if)#exit`	Exit interface mode.

RTR1 LDP-IGP Synchronization

Now that NSM, OSPF and LDP are all enabled, the LDP-IGP synchronization can be configured.

`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls ldp-igp sync ospf holddown-timer 120`	Enable LDP-IGP Synchronization for eth1 belonging to an OSPF process.120 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)#mpls ldp-igp sync-delay 30`	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. **LDP**: This command is part of LDP Process. **Default**: If not configured the delay is 0 seconds.
`(config-if)#exit`	Exit interface mode.

RTR2 LDP-IGP Synchronization

Now that NSM, OSPF and LDP are all enabled, the LDP-IGP synchronization configuration can be configured.

`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls ldp-igp sync ospf holddown-timer 120`	Enable LDP-IGP Synchronization for interfaces (eth1) belonging to an OSPF process.120secs is Holddown-timer value for IGP to wait until LDP Converge. **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.
`(config-if)#mpls ldp-igp sync-delay 30`	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)#exit`	Exit interface mode.

RTR1 Validation

Before LDP IGP SYNC is Achieved

```
RTR1#show ldp session

RTR1#show ldp adjacency

RTR1#show ip ospf interface
lo is up, line protocol is up
  Internet Address 192.168.0.1/32, Area 0.0.0.0, MTU 16436
  Process ID 100, Router ID 192.168.0.1, Network Type LOOPBACK, Cost: 10
  Transmit Delay is 1 sec, State Loopback, TE Metric 0
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
eth1 is up, line protocol is up
  Internet Address 1.1.1.1/24, Area 0.0.0.0, MTU 1500
  Process ID 100, Router ID 192.168.0.1, Network Type BROADCAST, Cost: 65535
  Transmit Delay is 1 sec, State Backup, Priority 1, TE Metric 65535
  LDP-OSPF Sync configured
    Holddown timer : 120 seconds, Remaining time = 102 seconds
  Designated Router (ID) 192.168.0.2, Interface Address 1.1.1.2
  Backup Designated Router (ID) 192.168.0.1, Interface Address 1.1.1.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:05
  Neighbor Count is 1, Adjacent neighbor count is 1
  Crypt Sequence Number is 282
  Hello received 161 sent 162, DD received 3 sent 4
  LS-Req received 1 sent 1, LS-Upd received 8 sent 8
  LS-Ack received 7 sent 6, Discarded 0

RTR1#show mpls ldp igp sync
lo is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth0 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth1 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization enabled.
  Session IP Address : NONE
    Sync status: Not achieved
    Delay timer: Configured, 30 seconds, Not Running
eth2 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth3 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth4 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth5 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth6 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
svlan0.1 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
RTR1#
```

After LDP IGP SYNC is Achieved

```
RTR1#show ldp adjacency
```

```
IP Address                 Intf Name    Holdtime   LDP-Identifier
1.1.1.2                       eth1             15
192.168.0.2:0
RTR1#

RTR1#show ldp session
Peer IP Address           IF Name    My Role    State
KeepAlive
192.168.0.2                 eth1           Passive      OPERATIONAL       30
RTR1#

RTR1#showow mpls ldp igp sync
lo is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth0 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth1 is up, line protocol is up
  LDP configured; LDP-IGP Synchronization enabled.
  Session IP Address : 192.168.0.2
    Sync status: Achieved
    Delay timer: Configured, 30 seconds, Not Running
eth2 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth3 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth4 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth5 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth6 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
svlan0.1 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
RTR1#

RTR1#show ip ospf interface
lo is up, line protocol is up
  Internet Address 192.168.0.1/32, Area 0.0.0.0, MTU 16436
  Process ID 100, Router ID 192.168.0.1, Network Type LOOPBACK, Cost: 10
  Transmit Delay is 1 sec, State Loopback, TE Metric 0
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
eth1 is up, line protocol is up
  Internet Address 1.1.1.1/24, Area 0.0.0.0, MTU 1500
  Process ID 100, Router ID 192.168.0.1, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State Backup, Priority 1, TE Metric 1
  LDP-OSPF Sync configured
    Holddown timer : 120 seconds, Remaining time = 0 seconds
  Designated Router (ID) 192.168.0.2, Interface Address 1.1.1.2
  Backup Designated Router (ID) 192.168.0.1, Interface Address 1.1.1.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:07
  Neighbor Count is 1, Adjacent neighbor count is 1
  Crypt Sequence Number is 282
  Hello received 115 sent 115, DD received 3 sent 4
  LS-Req received 1 sent 1, LS-Upd received 5 sent 5
  LS-Ack received 4 sent 3, Discarded 0
RTR1#
```


RTR2 Validation

Before LDP IGP SYNC is Achieved

```
RTR2#show ldp session

RTR2#show ldp adjacency

RTR2#show ip ospf interface
lo is up, line protocol is up
  Internet Address 192.168.0.2/32, Area 0.0.0.0, MTU 16436
  Process ID 100, Router ID 192.168.0.2, Network Type LOOPBACK, Cost: 10
  Transmit Delay is 1 sec, State Loopback, TE Metric 0
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
eth1 is up, line protocol is up
  Internet Address 1.1.1.2/24, Area 0.0.0.0, MTU 1500
  Process ID 100, Router ID 192.168.0.2, Network Type BROADCAST, Cost: 65535
  Transmit Delay is 1 sec, State DR, Priority 1, TE Metric 65535
  LDP-OSPF Sync configured
    Holddown timer : 120 seconds, Remaining time = 116 seconds
  Designated Router (ID) 192.168.0.2, Interface Address 1.1.1.2
  Backup Designated Router (ID) 192.168.0.1, Interface Address 1.1.1.1
  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
  Crypt Sequence Number is 382
  Hello received 240 sent 266, DD received 4 sent 3
  LS-Req received 1 sent 1, LS-Upd received 12 sent 13
  LS-Ack received 10 sent 12, Discarded 0

RTR2#show mpls ldp igp sync
lo is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth0 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth1 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization enabled.
  Session IP Address : NONE
    Sync status: Not achieved
    Delay timer: Configured, 30 seconds, Not Running
eth2 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth3 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth4 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
svlan0.1 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
RTR2#
```

After LDP-IGP SYNC is Achieved

```
RTR2#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive
192.168.0.1                  eth1          Active      OPERATIONAL        30
RTR2#
```

```
RTR2#show ldp adjacency
IP Address                 Intf Name    Holdtime   LDP-Identifier
1.1.1.1                       eth1              15
192.168.0.1:0
RTR2#

RTR2#show mpls ldp igp sync
lo is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth0 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth1 is up, line protocol is up
  LDP configured; LDP-IGP Synchronization enabled.
  Session IP Address : 192.168.0.1
    Sync status: Achieved
    Delay timer: Configured, 30 seconds, Not Running
eth2 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth3 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth4 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
svlan0.1 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
RTR2#

RTR2#show ip ospf interface
lo is up, line protocol is up
  Internet Address 192.168.0.2/32, Area 0.0.0.0, MTU 16436
  Process ID 100, Router ID 192.168.0.2, Network Type LOOPBACK, Cost: 10
  Transmit Delay is 1 sec, State Loopback, TE Metric 0
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
eth1 is up, line protocol is up
  Internet Address 1.1.1.2/24, Area 0.0.0.0, MTU 1500
  Process ID 100, Router ID 192.168.0.2, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DR, Priority 1, TE Metric 10
  LDP-OSPF Sync configured
    Holddown timer : 120 seconds, Remaining time = 0 seconds
  Designated Router (ID) 192.168.0.2, Interface Address 1.1.1.2
  Backup Designated Router (ID) 192.168.0.1, Interface Address 1.1.1.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:03
  Neighbor Count is 1, Adjacent neighbor count is 1
  Crypt Sequence Number is 382
  Hello received 155 sent 182, DD received 4 sent 3
  LS-Req received 1 sent 1, LS-Upd received 6 sent 5
  LS-Ack received 3 sent 6, Discarded 0
RTR2#
```

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.

RTR1

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.

NSM

`#configuration terminal`	Enter configuration mode
`(config)#interface eth1`	Enter interface mode.
`(config-if)#ip address 1.1.1.1/24`	Set the IP address of the eth1 to `1.1.1.1/24`
`(config-if)#label-switching`	Enable label switching on eth1.
`(config-if)#exit`	Exit the Interface mode and return to the Configure mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 192.168.0.1/32`	Set the IP address of the loopback interface to 192.168.0.1/32.
`(config-if)#exit`	Exit the Interface mode and return to the Configure mode.

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 eth1`	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 the Interface mode and return to the Configure 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)#exit`	Exit the Interface mode and return to the Configure mode.

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 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 eth1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on eth1.
(config-if)#exit	Exit interface mode.

RTR2

Before configuring LDP-IGP synchronization, the NSM, OSPF and LDP configurations must be completed. The tables below contain examples of how this is done.

NSM

#configuration terminal	Enter configuration mode
(config)#interface eth1	Enter interface mode.
(config-if)#ip address 1.1.1.2/24	Set the IP address of eth1 to `1.1.1.2/24`
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#exit	Exit the Interface mode and return to the Configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 192.168.0.2/32	Set the IP address of the loopback interface to 192.168.0.2/32.
(config-if)#exit	Exit the Interface mode and return to the Configure mode.

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 eth1	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 the Interface mode and return to the Configure 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)#exit`	Exit the Interface mode and return to the Configure mode.

LDP

`(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 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 eth1`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on eth1.
`(config-if)#exit`	Exit interface mode.

RTR1 LDP-IGP SYNC Configuration

Now that NSM, IS-IS and LDP are all enabled, the LDP-IGP synchronization can be configured.

`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls ldp-igp sync isis level-1 holddown-timer 120`	Configure LDP-IGP Synchronization for interface eth1 belonging to an IS-IS process with corresponding IS-IS level.120 seconds is the holddown-timer value for IGP to wait until LDP converges. 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. **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.
`(config-if)#mpls ldp-igp sync-delay 30`	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. **LDP**: This command is part of LDP Process. **Default**: If not configured, the delay is 0 seconds.
`(config-if)#exit`	Exit interface mode.

RTR2 LDP-IGP SYNC Configuration

Now that NSM, IS-IS and LDP are all enabled, the LDP-IGP synchronization can be configured.

`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls ldp-igp sync isis level-1 holddown-timer 120`	Configure LDP-IGP Synchronization for interface eth1 belonging to an IS-IS process with corresponding IS-IS level.120secs is the holddown-timer value for IGP to wait until LDP converges. 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. **IS-IS**: This command is part of IS-IS Process. **Default**: Mandatory configuration. No default option. **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.
`(config-if)#mpls ldp-igp sync-delay 30`	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)#exit`	Exit interface mode.

RTR1 Validation

Before LDP-IGP Synchronization is Achieved

```
RTR1#show ldp adjacency

RTR1#show isis interface
lo is up, line protocol is up
  Routing Protocol: IS-IS (1)
    Network Type: Loopback
    Circuit Type: level-1
    Local circuit ID: 0x01
    Extended Local circuit ID: 0x00000001
    IP interface address:
      127.0.0.1/8
      192.168.0.1/32
    IPv6 interface address:
      ::1/128
    Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0000.00
    Number of active level-1 adjacencies: 0
    Level-1 LSP MTU: 1492
eth0 is up, line protocol is up
  IS-IS not enabled on this interface
eth1 is up, line protocol is up
  Routing Protocol: IS-IS (1)
    Network Type: Broadcast
```

```
    Circuit Type: level-1
    Local circuit ID: 0x02
    Extended Local circuit ID: 0x00000003
    Local SNPA: 0002.a54e.de10
    IP interface address:
      1.1.1.1/24
    IPv6 interface address:
      fe80::202:a5ff:fe4e:de10/64
    LDP-ISIS Sync Configured
      Holddown timer = 120 seconds, Remaining time = 82 seconds
    Level-1 Metric: 63/16777214, Priority: 64, Circuit ID: 0000.0000.0001.02
    Number of active level-1 adjacencies: 1
    Level-1 LSP MTU: 1492
    Next IS-IS LAN Level-1 Hello in 1 seconds
eth2 is down, line protocol is down
  IS-IS not enabled on this interface
eth3 is up, line protocol is up
  IS-IS not enabled on this interface
eth4 is up, line protocol is up
  IS-IS not enabled on this interface
eth5 is down, line protocol is down
  IS-IS not enabled on this interface
eth6 is down, line protocol is down
  IS-IS not enabled on this interface
svlan0.1 is down, line protocol is down
  IS-IS not enabled on this interface
RTR1#

RTR1#show mpls ldp igp sync
lo is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth0 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth1 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization enabled.
  Session IP Address : NONE
    Sync status: Not achieved
    Delay timer: Configured, 30 seconds, Not Running
eth2 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth3 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth4 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth5 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth6 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
svlan0.1 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
RTR1#
```

After LDP-IGP Synchronization is Achieved

```
RTR1#show ldp session
Peer IP Address           IF Name    My Role    State
KeepAlive
192.168.0.2                  eth1           Passive     OPERATIONAL   30
```

```
RTR1#

RTR1#show ldp adjacency
IP Address                 Intf Name    Holdtime   LDP-Identifier
1.1.1.2                       eth1        15                 192.168.0.2:0
RTR1#

RTR1#show isis interface
lo is up, line protocol is up
  Routing Protocol: IS-IS (1)
    Network Type: Loopback
    Circuit Type: level-1
    Local circuit ID: 0x01
    Extended Local circuit ID: 0x00000001
    IP interface address:
      127.0.0.1/8
      192.168.0.1/32
    IPv6 interface address:
      ::1/128
    Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0000.00
    Number of active level-1 adjacencies: 0
    Level-1 LSP MTU: 1492
eth0 is up, line protocol is up
  IS-IS not enabled on this interface
eth1 is up, line protocol is up
  Routing Protocol: IS-IS (1)
    Network Type: Broadcast
    Circuit Type: level-1
    Local circuit ID: 0x02
    Extended Local circuit ID: 0x00000003
    Local SNPA: 0002.a54e.de10
    IP interface address:
      1.1.1.1/24
    IPv6 interface address:
      fe80::202:a5ff:fe4e:de10/64
    LDP-ISIS Sync Configured
      Holddown timer = 120 seconds, Remaining time = 0 seconds
    Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0001.02
    Number of active level-1 adjacencies: 1
    Level-1 LSP MTU: 1492
    Next IS-IS LAN Level-1 Hello in 1 seconds
eth2 is down, line protocol is down
  IS-IS not enabled on this interface
eth3 is up, line protocol is up
  IS-IS not enabled on this interface
eth4 is up, line protocol is up
  IS-IS not enabled on this interface
eth5 is down, line protocol is down
  IS-IS not enabled on this interface
eth6 is down, line protocol is down
  IS-IS not enabled on this interface
svlan0.1 is down, line protocol is down
  IS-IS not enabled on this interface
RTR1#

RTR1#show mpls ldp igp sync
lo is up, line protocol is up
```

```
  LDP not configured; LDP-IGP Synchronization not enabled.
eth0 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth1 is up, line protocol is up
  LDP configured; LDP-IGP Synchronization enabled.
  Session IP Address : 192.168.0.2
    Sync status: Achieved
    Delay timer: Configured, 30 seconds, Not Running
eth2 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth3 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth4 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth5 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth6 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
svlan0.1 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
RTR1#
```

RTR2 Validation

Before LDP-IGP Synchronization is Achieved

```
RTR2#show ldp session

RTR2#show ldp adjacency

RTR2#show mpls ldp igp sync
lo is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth0 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth1 is up, line protocol is up
  LDP configured; LDP-IGP Synchronization enabled.
  Session IP Address : NONE
    Sync status: Not achieved
    Delay timer: Configured, 30 seconds, Not Running
eth2 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth3 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth4 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
svlan0.1 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
RTR2#

RTR2#show isis interface
lo is up, line protocol is up
  Routing Protocol: IS-IS (1)
    Network Type: Loopback
    Circuit Type: level-1
    Local circuit ID: 0x01
```



```
      Extended Local circuit ID: 0x00000001
      IP interface address:
        127.0.0.1/8
        192.168.0.2/32
      IPv6 interface address:
        ::1/128
      Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0000.00
      Number of active level-1 adjacencies: 0
      Level-1 LSP MTU: 1492
  eth0 is up, line protocol is up
    IS-IS not enabled on this interface
  eth1 is up, line protocol is up
    Routing Protocol: IS-IS (1)
      Network Type: Broadcast
      Circuit Type: level-1
      Local circuit ID: 0x02
      Extended Local circuit ID: 0x00000003
      Local SNPA: 0002.a54e.d452
      IP interface address:
        1.1.1.2/24
      IPv6 interface address:
        fe80::202:a5ff:fe4e:d452/64
      LDP-ISIS Sync Configured
        Holddown timer = 120 seconds, Remaining time = 16 seconds
      Level-1 Metric: 63/16777214, Priority: 64, Circuit ID: 0000.0000.0001.02
      Number of active level-1 adjacencies: 1
      Level-1 LSP MTU: 1492
      Next IS-IS LAN Level-1 Hello in 7 seconds
  eth2 is down, line protocol is down
    IS-IS not enabled on this interface
  eth3 is down, line protocol is down
    IS-IS not enabled on this interface
  eth4 is down, line protocol is down
    IS-IS not enabled on this interface
  svlan0.1 is down, line protocol is down
    IS-IS not enabled on this interface
  RTR2#
```

After LDP-IGP Synchronization is Achieved

```
RTR2#show ldp session
Peer IP Address           IF Name    My Role    State
KeepAlive
192.168.0.1                  eth1          Active       OPERATIONAL   30

RTR2#show ldp adjacency
IP Address                  Intf Name    Holdtime   LDP-Identifier
1.1.1.1                        eth1             15
192.168.0.1:0
RTR2#

RTR2#show isis interface
lo is up, line protocol is up
  Routing Protocol: IS-IS (1)
    Network Type: Loopback
    Circuit Type: level-1
    Local circuit ID: 0x01
    Extended Local circuit ID: 0x00000001
```



```
    IP interface address:
      127.0.0.1/8
      192.168.0.2/32
    IPv6 interface address:
      ::1/128
    Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0000.00
    Number of active level-1 adjacencies: 0
    Level-1 LSP MTU: 1492
eth0 is up, line protocol is up
  IS-IS not enabled on this interface
eth1 is up, line protocol is up
  Routing Protocol: IS-IS (1)
    Network Type: Broadcast
    Circuit Type: level-1
    Local circuit ID: 0x02
    Extended Local circuit ID: 0x00000003
    Local SNPA: 0002.a54e.d452
    IP interface address:
      1.1.1.2/24
    IPv6 interface address:
      fe80::202:a5ff:fe4e:d452/64
    LDP-ISIS Sync Configured
      Holddown timer = 120 seconds, Remaining time = 0 seconds
    Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0001.02
    Number of active level-1 adjacencies: 1
    Level-1 LSP MTU: 1492
    Next IS-IS LAN Level-1 Hello in 4 seconds
eth2 is down, line protocol is down
  IS-IS not enabled on this interface
eth3 is down, line protocol is down
  IS-IS not enabled on this interface
eth4 is down, line protocol is down
  IS-IS not enabled on this interface
svlan0.1 is down, line protocol is down
  IS-IS not enabled on this interface
RTR2#

RTR2#show mpls ldp igp sync
lo is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth0 is up, line protocol is up
  LDP not configured; LDP-IGP Synchronization not enabled.
eth1 is up, line protocol is up
  LDP configured; LDP-IGP Synchronization enabled.
  Session IP Address : 192.168.0.1
    Sync status: Achieved
    Delay timer: Configured, 30 seconds, Not Running
eth2 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth3 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
eth4 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
svlan0.1 is down, line protocol is down
  LDP not configured; LDP-IGP Synchronization not enabled.
RTR2#
```

CHAPTER 4 RSVP-TE Configuration

This chapter contains configurations for Resource Reservation Protocol - Traffic Engineering (RSVP-TE).

For details about the commands, see the *RSVP-TE Command Reference*.

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.

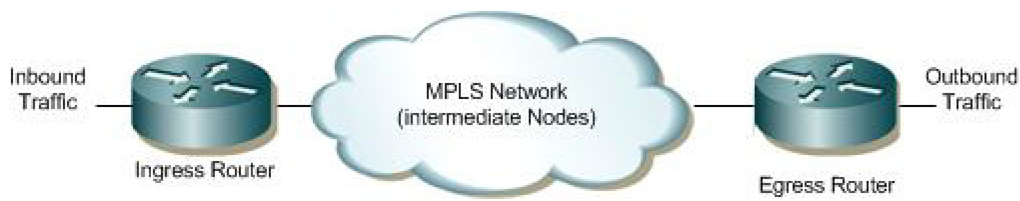


Figure 4-1: Basic RSVP-TE Topology

RSVP-TE Architecture

RSVP-TE is a signaling protocol that supports explicit routing capabilities to establish LSPs in a MPLS network. ZebOS-XP 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.
- preempts existing LSPs with lower priority in order to accommodate an LSP with a higher priority (this functionality is part of the Quality of Services module of the NSM).
- 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).
- supports integrated services through the exchange of Integrated Services (IntSrv) objects in RSVP messages.
- provides statistical information of RSVP messages exchanged.

In addition, ZebOS-XP 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. Configure Diffserv-TE for builds which support them
2. Enable label-switching and RSVP-TE on all participating interfaces.
3. 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.

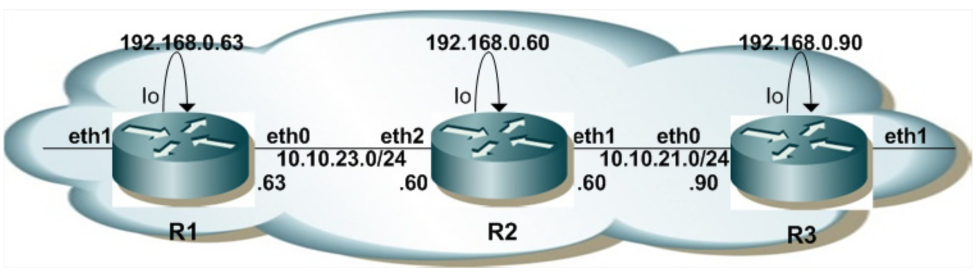


Figure 4-2: Topology for Minimal Configuration

Configure DiffServ-TE

Define the DiffServ administration groups, class types, and TE classes for all routers.

R1 - NSM

`ZebOS-XP#configure terminal`	Enter configure mode.
`ZebOS-XP(config)#mpls class-type ct0 default`	Define class type names and enable class types.
`ZebOS-XP(config)#mpls te-class te0 default 0`	Define the DiffServ TE class, class type name, and preemption priority.
`ZebOS-XP(config)#mpls te-class te7 default 7`	Define the DiffServ TE class, class type name, and preemption priority.

For builds where Diffserv and DSTE are disabled, the following setup commands will serve as minimum configurations

R1

NSM

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 192.168.0.63/24	Set the IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#interface eth0	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 eth0.
(config-if)#exit	Exit interface mode.

RSVP-TE

(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface eth0	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.

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 10.10.23.0/24 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)#exit	Exit Router mode.

R2

NSM

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 192.168.0.63/24	Set the IP address for the interface.
(config-if)#exit	Enable label switching on interface lo.
(config)#interface eth2	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 eth2.

`(config-if)#exit`	Exit interface mode.
`(config)#interface eth1`	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 `eth1`.
`(config-if)#exit`	Exit interface mode.

RSVP-TE

`(config)#router rsvp`	Enter `Configure Router` mode.
`(config-router)#exit`	Exit `Router` mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#exit`	Exit interface mode.

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 10.10.23.0/24 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`	Define the second network `(10.10.21.0/24)` on which OSPF runs and associate the area ID `(0)`.
`(config-router)#network 192.168.0.63/32 area 0`	Set the IP address of the loopback interface to `192.168.0.63/32`.
`(config-router)#exit`	Exit `Router` mode.

R3

NSM

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 192.168.0.90/24`	Set the IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth0`	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 `eth0`.
`(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 `eth1`.
`(config-if)#exit`	Exit interface mode.

RSVP-TE

`(config)#router rsvp`	Enter `Configure Router` mode.
`(config-router)#exit`	Exit `Router` mode.
`(config)#interface eth0`	Enter interface mode.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#exit`	Exit interface mode.

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 10.10.21.0/24 area 0`	Define the network `(10.10.21.0/24)` 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)#exit`	Exit `Router` mode.

Establish a Trunk with CSPF Disabled

ZebOS-XP, 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.

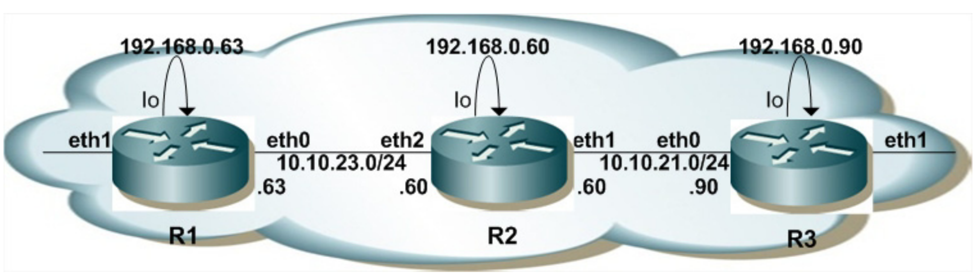


Figure 4-3: Basic Topology

R1 - RSVP-TE

`#configure terminal`	Enter configure mode.
`(config)#rsvp-trunk T1`	Create an RSVP trunk `T1` and enter the Trunk mode.

(config-trunk)#primary no-cspf	Specify no-cspf since CSPF is enabled by default.
(config-trunk)#to 192.168.0.90	Specify the IPv4 egress (destination point) for the LSP.

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 ZebOS-XP 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.

R1 (RSVP Daemon)

#configure terminal	Enter configure mode.
(config)#rsvp-trunk T1	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.

Mapping a route to a trunk

In the ZebOS 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.

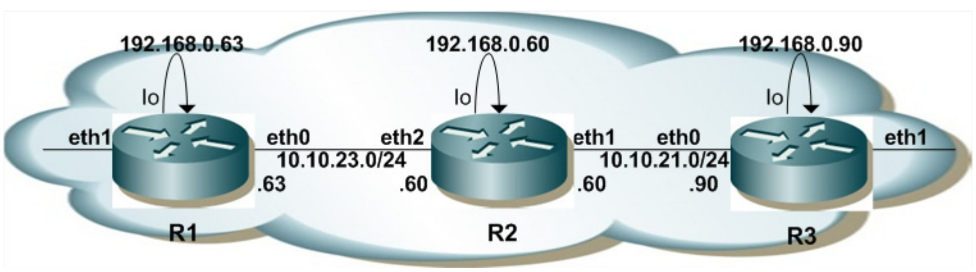


Figure 4-4: Topology for route mapping

R1 - RSVP-TE

ZebOS-XP#configure terminal	Enter configure mode.
ZebOS-XP(config)#rsvp-trunk T1	Create an RSVP trunk T1 and enter the Trunk mode.
ZebOS-XP(config-trunk)#map-route 90.90.90.0/24	Specify the destination prefix that needs to mapped to this trunk.
ZebOS-XP(config-trunk)#to 192.168.0.90	Specify the IPv4 egress (destination point) for the LSP.

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 R3 is defined as loose hop, R2 can use R4 as an intermediate hop to reach R3. However, if it was a strict hop, then R2 would have to use interface `eth1` to reach R3 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.

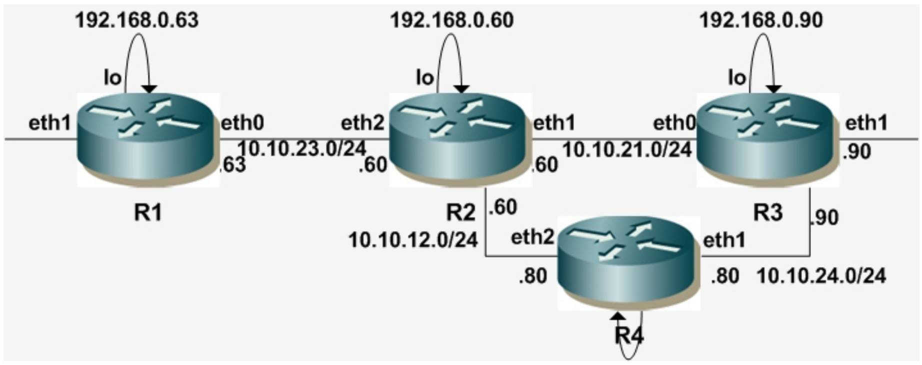


Figure 4-5: Topology for Explicitly Defined Path

R1 - 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)#primary no-cspf`	Since CSPF is enabled by default, specify `no-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)#exit`	Exit `Trunk` mode.

Reserve Bandwidth for A Trunk

Configuring the reservable bandwidth specifies the maximum bandwidth available to RSVP-TE for reservations. Using the `bandwidth` command specifies the total bandwidth on an interface.

To reserve bandwidth for the trunk:

1. Configure bandwidth on all participating interfaces.
2. Configure reservable bandwidth on NSM
3. Configure bandwidth on the trunk.

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.

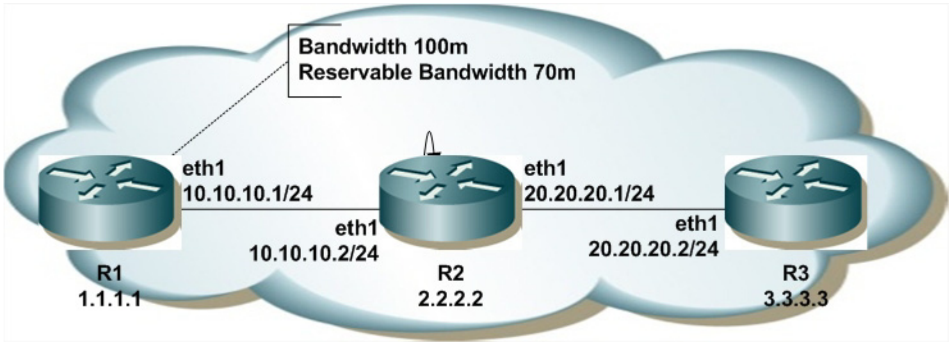


Figure 4-6: Bandwidth Topology

R1 - NSM

`#configure terminal`	Enter configure mode.
`(config)#interface eth0`	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 `eth0`.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#bandwidth 100m`	Specify the maximum bandwidth (in bits per second) to be used by this interface.
`(config-if)#reservable-bandwidth 70m`	Specify the maximum reservable bandwidth per interface.
`(config-if)#exit`	Exit interface mode.

R1 - RSVP-TE

`#configure terminal`	Enter configure mode.
`(config)#rsvp-path myPath`	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 `Trunk` mode.
`(config-trunk)#primary no-cspf`	Since CSPF is enabled by default, specify `no-cspf` if CSPF is not required.
`(config-trunk)#primary path myPath`	Specify an RSVP path to be used.
`(config-trunk)#primary bandwidth 10m`	Reserve the bandwidth in bits per second for the current trunk `T1`.
`(config-trunk)#to 192.168.0.90`	Specify the IPv4 egress (destination point) for the LSP.
`(config-trunk)#exit`	Exit `Trunk` mode.

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.

R1 - 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)#primary no-cspf`	Since CSPF is enabled by default, specify `no-cspf` if CSPF is not required.
`(config-trunk)#primary path myPath`	Specify an RSVP path to be used.
`(config-trunk)#primary bandwidth 10m`	Reserve the bandwidth in bits per second for the primary LSP of trunk `T1`.
`(config-trunk)#secondary no-cspf`	Specify the `no-cspf` option for the Secondary LSP.
`(config-trunk)#secondary path myPath2`	Specify an RSVP path to be used.
`(config-trunk)#secondary bandwidth 10m`	Configure the Secondary LSP bandwidth in bits per second for the current trunk `T1`.
`(config-trunk)#secondary setup-priority 5`	Configure a `setup-priority` value of 5.
`(config-trunk)#secondary hold-priority 3`	Configure the hold priority value for the current trunk `T1`.
`(config-trunk)#to 192.168.0.90`	Specify the IPv4 egress (destination point) for the LSP.
`(config-trunk)#exit`	Exit `Trunk` mode.

Validation

This example shows the number of configured RSVP sessions in a router.

```
#show rsvp session count
Total configured: 50000, Up 50000, Down 0

Total ingress sessions: 50000, Up 50000, Down 0
Total transit sessions: 0, Up 0, Down 0
Total egress sessions: 0, Up 0, Down 0
```

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.

R1 - NSM

`#configure terminal`	Enter configure mode.

`(config)#mpls admin-group A 0`
`(config)#mpls admin-group B 1`
`(config)#mpls admin-group C 2`
`(config)#mpls admin-group D 3`
`(config)#mpls admin-group E 4`
	Add new administrative groups, specify their names and assign bit values to them.

`(config)#interface eth0`	Enter interface mode.

`(config-if)#admin-group A`
`(config-if)#admin-group B`
`(config-if)#admin-group C`
	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)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#admin-group E` `(config-if)#admin-group D`	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)#exit`	Exit interface mode.

R2 - NSM

`#configure terminal`	Enter configure mode.
`(config)#mpls admin-group A 0` `(config)#mpls admin-group C 2`	Add new administrative groups and specify their names and assign bit values to them.
`(config)#interface eth2`	Enter interface mode
`(config-if)#admin-group A` `(config-if)#admin-group C`	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)#exit`	Exit interface mode.

R1 - RSVP-TE

`#configure terminal`	Enter configure mode.
`(config)#rsvp-trunk T1`	Create an RSVP trunk `T1` and enter the Trunk mode.
`(config-trunk)#primary no-cspf`	Since CSPF is enabled by default, specify `no-cspf` if CSPF is not required.
`(config-trunk)#primary path P1`	Specify an RSVP primary path to be used.
`(config-trunk)#primary bandwidth 10m`	Reserve the bandwidth in bits per second for the current trunk `T1`.
`(config-trunk)#primary no-cspf`	Specify the `no-cspf` option for the LSP.
`(config-trunk)#primary bandwidth 10m`	Reserve bandwidth in bits per second for the current trunk `T1`.
`(config-trunk)#primary setup-priority 6`	Configure a setup priority value of 5.
`(config-trunk)#primary hold-priority 4`	Configure the hold priority value for the primary LSP of trunk `T1`.
`(config-trunk)#primary include-any A`	Set up the LSP with admin group constraint A.
`(config-trunk)#primary include-any C`	Set up the LSP with admin group constraint C.
`(config-trunk)#secondary setup-priority 5`	Configure a setup priority value of 5 for the Secondary LSP.
`(config-trunk)#secondary hold-priority 3`	Configure the hold priority value for the Secondary LSP.
`(config-trunk)#to 192.168.0.90`	Specify the IPv4 egress (destination point) for the LSP.

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 R2 (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.

R1 - 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 30`	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.

R2 - 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 30	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.

Enable RSVP-TE Graceful Restart

Graceful Restart supports preservation of labels and forwarding information when the RSVP-TE process restarts or goes from primary to back-up, or the route processor undergoes stateful switchover.

R1 - RSVP-TE

#configure terminal	Enter Configure mode.
(config)#router rsvp	Enter Router mode from Configure mode, and enable the RSVP daemon.
(config-router)#neighbor 172.16.20.1	Explicitly specify the neighbor with which to exchange Hello messages.
(config-router)#hello-receipt	Enable the receipt of Hello messages from peers.
(config-router)#graceful-restart enable	Enable Graceful Restart capability on the router.
(config-router)#exit	Exit Router mode.

Enable IGP Shortcut

The Interior Gateway Protocol (IGP) Shortcut lets link-state IGPs calculate IP routes to forward traffic over tunnels set up by TE. Before enabling RSVP LSP for IGP Shortcut use, an RSVP trunk must be configured as shown in the following topology.

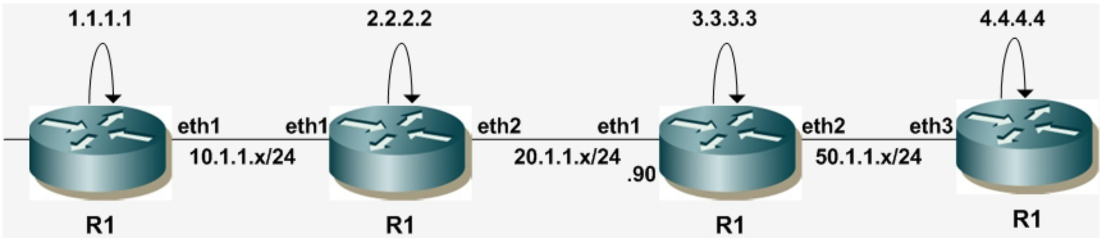


Figure 4-7: Topology Example for IGP Shortcut

The following steps outline the process of configuring the RSVP trunk and enabling RSVP LSP for IGP Shortcut use. The configuration given is for router R1.

1. Configure DiffServ-TE.
2. Configure an IP address for all connected interfaces and loopback interfaces.
3. Configure OSPF, and add the networks configured in the router.
4. Enable label switching on the interfaces.
5. Configure RSVP-TE globally and enable on the interfaces.
6. Enable IGP shortcut.

Configure DiffServ-TE

Define the DiffServ administration groups, class types, and TE classes for all routers.

R1 - NSM

`#configure terminal`	Enter configure mode.
`(config)#mpls admin-group a 0`	Add new administrative groups, specify their names, and assign bit values to them.
`(config)#mpls admin-group b 1`	
`(config)#mpls admin-group c 2`	
`(config)#mpls admin-group d 3`	
`(config)#mpls class-type ct0 default`	Define class type names and enable class types.
`(config)#mpls class-type ct1 a1`	
`(config)#mpls class-type ct2 a2`	
`(config)#mpls class-type ct3 a3`	
`(config)#mpls class-type ct4 a4`	
`(config)#mpls class-type ct5 a5`	
`(config)#mpls class-type ct6 a6`	
`(config)#mpls class-type ct7 a7`	

`(config)#mpls te-class te0 a2 5`	Define the DiffServ TE class, class type name, and preemption priority.
`(config)#mpls te-class te1 a2 4`	
`(config)#mpls te-class te2 default 2`	
`(config)#mpls te-class te3 default 4`	
`(config)#mpls te-class te4 default 5`	
`(config)#mpls te-class te5 default 0`	
`(config)#mpls te-class te6 default 3`	
`(config)#mpls te-class te7 default 7`	

Note: Map the bandwidth to different TE classes, and define administration groups for the interface. Repeat for all interfaces.

R1 - NSM

`#configure terminal`	Enter configure mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#bandwidth 100m`	Reserve bandwidth, and configure the bandwidth constraint for each class type on the eth1 interface.
`(config-if)#reservable-bandwidth 100m`	
`(config-if)#bandwidth-constraint a1 100m`	
`(config-if)#bandwidth-constraint a2 100m`	
`(config-if)#bandwidth-constraint a3 100m`	
`(config-if)#bandwidth-constraint a4 100m`	
`(config-if)#bandwidth-constraint a5 100m`	
`(config-if)#bandwidth-constraint a6 100m`	
`(config-if)#bandwidth-constraint a7 100m`	
`(config-if)#admin-group a`	Add an administrative group 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`	
`(config-if)#admin-group d`	

Configure IP Addresses

Configure the IP address on all connected interfaces and loopback interfaces.

R1

`#configure terminal`	Enter configure mode.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#ip address 10.1.1.66/64`	Set the IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Specify the interface `(eth2)` to be configured.
`(config-if)#ip address 30.1.1.66/64`	Set the IP address for the interface.
`(config-if)#exit`	Exit interface mode.

(config)#interface lo	Specify the loopback interface (lo) 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)#exit	Exit interface mode.

Configure OSPF

Configure OSPF and add the networks configured in the router.

R1 - OSPF

(config)#router ospf	Enter the Router mode.
(config-router)#network 1.1.1.1/32 area 0 (config-router)#network 10.1.1.0/24 area 0 (config-router)#network 30.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0).
(config-router)#exit	Exit Router mode.

Enable Label Switching

Enable label switching on the interfaces.

R1 - NSM

#configure terminal	Enter configure mode.
(config)#interface eth1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#exit	Exit interface mode.

Configure RSVP-TE

Configure RSVP-TE globally and enable on the interfaces.

R1 - RSVP-TE

#configure terminal	Enter configure mode.
(config)#router rsvp	Enable RSVP globally.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth1	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.

Enable IGP Shortcut

The following example describes how to enable RSVP LSP for IGP Shortcut use.

R1 - RSVP-TE

#configure terminal	Enter configure mode.
(config)#rsvp-trunk t1	Create an RSVP trunk t1 and enter the Trunk mode.
(config-trunk)#to 3.3.3.3	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#enable-igp-shortcut	Enable RSVP LSP for IGP Shortcut use.
(config-trunk)#exit	Exit Trunk mode.

Validation

Use the show mpls forwarding-table command to display all LSPs originating from this router.

```
#show mpls forwarding-table
Codes: > - selected FTN, p - stale FTN, B - BGP FTN, K - CLI FTN,
       L - LDP FTN,   R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut
       U - unknown FTN
Code  FEC          Tunnel-id FTN-ID Pri  Nexthop   Out-Label  Out-Intf LSP-Type
R>    3.3.3.3/32     101       1    Yes  10.1.1.2  52480      eth1     LSP_DEFAULT
I>    4.4.4.4/32     101       2    Yes  10.1.1.2  52480      eth1     LSP_DEFAULT
I>    50.1.1.0/24    101       3    Yes  10.1.1.2  52480      eth1     LSP_DEFAULT
```

Disable IGP Shortcut

The following example describes how to disable IGP Shortcut.

R1 - RSVP-TE

#configure terminal	Enter configure mode.
(config)#rsvp-trunk t1	Create an RSVP trunk t1 and enter the Trunk mode.
(config-trunk)#to 3.3.3.3	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#disable-igp-shortcut	Disable RSVP LSP for IGP Shortcut use.
(config-trunk)#exit	Exit Trunk mode.

Fast Reroute Configuration

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. Whenever a link or node fails, FRR is able to recover impacted traffic flows in the level of 50 milliseconds.

Figure 4-8 is a simple topology example for FRR:

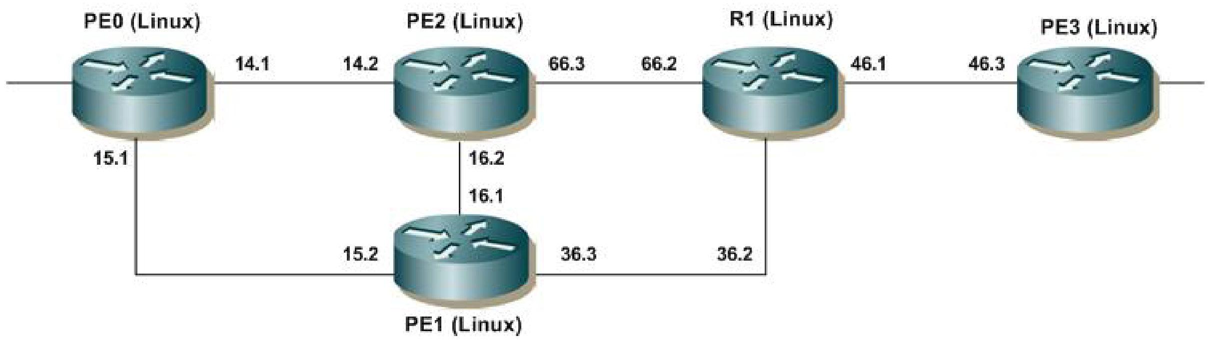


Figure 4-8: Topology Example for Fast Reroute

PE0

`#configure terminal`	Enter configure mode.
`(config)#mpls class-type ct0 class0`	Define class type names, and enable class types.
`(config)#mpls te-class te0 class0 0`	
`(config)#mpls te-class te1 class0 1`	
`(config)#mpls te-class te2 class0 2`	
`(config)#mpls te-class te3 class0 3`	
`(config)#mpls te-class te4 class0 4`	
`(config)#mpls te-class te5 class0 5`	
`(config)#mpls te-class te6 class0 6`	
`(config)#mpls te-class te7 class0 7`	
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 26.26.26.26/32 secondary`	Set a secondary IP address of the interface to `26.26.26.26/32`.
`(config-if)#no shutdown`	Administratively shut down the interface.
`(config-if)#exit`	Exit the `Interface` mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on interface `eth1`.
`(config-if)#bandwidth 100m`	Reserve bandwidth, and configure the bandwidth constraint for each class type on the `eth1` interface.
`(config-if)#reservable-bandwidth 100m`	Set the reservable bandwidth parameter
`(config-if)#bandwidth-constraint class0 100m`	Set the bandwidth constraint parameter
`(config-if)#ip address 15.0.0.1/8`	Set an IP address of the interface to `15.0.0.1/8`.
`(config-if)#no shutdown`	Administratively shut down the interface.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#exit`	Exit the `Interface` mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on interface `eth2`.
`(config-if)#bandwidth 100m`	Reserve bandwidth, and configure the bandwidth constraint for each class type on the `eth1` interface.
`(config-if)#reservable-bandwidth 100m`	Set the reservable bandwidth parameter

`(config-if)#bandwidth-constraint class0 100m`	Set the bandwidth constraint parameter
`(config-if)#ip address 14.0.0.1/8`	Set an IP address of the interface to `14.0.0.1/8`.
`(config-if)#no shutdown`	Administratively shut down the interface.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#exit`	Exit the `Interface` mode.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#ip address 17.0.0.1/8`	Set an IP address of the interface to `17.0.0.1/8`.
`(config-if)#no shutdown`	Administratively shut down the interface.
`(config-if)#exit`	Exit the `Interface` mode.
`(config)#router ospf`	Enter the `router configure` mode for `ospf`.
`(config-router)#network 14.0.0.0/8 area 5`	Define the network `(14.0.0.0/8)` on which OSPF runs and associate the area ID `(5)`.
`(config-router)#network 15.0.0.0/8 area 5`	Define the network `(15.0.0.0/8)` on which OSPF runs and associate the area ID `(5)`.
`(config-router)#network 26.26.26.26/32 area 5`	Define the network `(26.26.26.26/32)` on which OSPF runs and associate the area ID `(5)`.
`(config-router)#exit`	Exit the `router configure` mode.
`(config)#rsvp-path pb1`	Enter the `path` mode for `rsvp pb1`.
`(config-path)#15.0.0.2 strict`	Configure this explicit route path as a `strict` hop.
`(config-path)#36.0.0.2 strict`	Configure this explicit route path as a `strict` hop.
`(config)#exit`	Exit the `path` mode.
`(config)#rsvp-path pt1`	Enter the `path` mode for `rsvp pt1`.
`(config-path)#14.0.0.2 strict`	Configure this explicit route path as a `strict` hop.
`(config-path)#66.0.0.2 strict`	Configure this explicit route path as a `strict` hop.
`(config-path)#46.0.0.3 strict`	Configure this explicit route path as a `strict` hop.
`(config)#exit`	Exit the `path` mode.
`(config)#rsvp-path pt2`	Enter the `path` mode for `rsvp pt2`.
`(config-path)#15.0.0.2 strict`	Configure this explicit route path as a `strict` hop.
`(config-path)#36.0.0.2 strict`	Configure this explicit route path as a `strict` hop.
`(config-path)#46.0.0.3 strict`	Configure this explicit route path as a `strict` hop.
`(config)#exit`	Exit the `path` mode.
`(config)#rsvp-path plink`	Enter the `path` mode for `rsvp plink`.
`(config-path)#15.0.0.2 strict`	Configure this explicit route path as a `strict` hop.
`(config-path)#16.0.0.2 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 fast-reroute protection facility`	Configure primary fast-reroute protection facility for a trunk.
`(config-trunk)#primary fast-reroute bandwidth 100m`	Configure primary fast-reroute protection facility for a trunk.
`(config-trunk)#primary path pt1`	Configure trunk `T1` to use the defined path.

(config-trunk)#to 30.30.30.30	Specify the IPv4 egress (destination point) for the LSP.
(config)#exit	Exit the path mode.

PE1

#configure terminal	Enter configure mode.
(config)#mpls class-type ct0 class0	Define class type names, and enable class types.
(config)#mpls te-class te0 class0 0	
(config)#mpls te-class te1 class0 1	
(config)#mpls te-class te2 class0 2	
(config)#mpls te-class te3 class0 3	
(config)#mpls te-class te4 class0 4	
(config)#mpls te-class te5 class0 5	
(config)#mpls te-class te6 class0 6	
(config)#mpls te-class te7 class0 7	
(config)#interface lo	Enter interface mode.
(config-if)#ip address 27.27.27.27/32 secondary	Set a secondary IP address of the interface to 27.27.27.27/32.
(config-if)#no shutdown	Administratively shut down the interface.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#bandwidth 100m	Reserve bandwidth, and configure the bandwidth constraint for each class type on the eth1 interface.
(config-if)#reservable-bandwidth 100m	Set the reservable bandwidth parameter
(config-if)#bandwidth-constraint class0 100m	Set the bandwidth constraint parameter
(config-if)#ip address 15.0.0.2/8	Set an IP address of the interface to 15.0.0.2/8.
(config-if)#no shutdown	Administratively shut down the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#bandwidth 100m	Reserve bandwidth, and configure the bandwidth constraint for each class type on the eth1 interface.
(config-if)#reservable-bandwidth 100m	Set the reservable bandwidth parameter
(config-if)#bandwidth-constraint class0 100m	Set the bandwidth constraint parameter
(config-if)#ip address 16.0.0.1/8	Set an IP address of the interface to 16.0.0.1/8.
(config-if)#no shutdown	Administratively shut down the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth3	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface eth2.

(config-if)#bandwidth 100m	Reserve bandwidth, and configure the bandwidth constraint for each class type on the eth1 interface.
(config-if)#reservable-bandwidth 100m	Set the reservable bandwidth parameter
(config-if)#bandwidth-constraint class0 100m	Set the bandwidth constraint parameter
(config-if)#ip address 36.0.0.3/8	Set an IP address of the interface to 36.0.0.3/8.
(config-if)#no shutdown	Administratively shut down the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit the Interface mode.
(config)#router ospf	Enter the router configure mode for ospf.
(config-router)#timers spf exp 500 50000	Set the routing timer for a SPF timer to use exponential back off delay.
(config-router)#network 15.0.0.0/8 area 5	Define the network (15.0.0.0/8) on which OSPF runs and associate the area ID (5).
(config-router)#network 16.0.0.0/8 area 5	Define the network (16.0.0.0/8) on which OSPF runs and associate the area ID (5).
(config-router)#network 27.27.27.27/32 area 5	Define the network (27.27.27.27/32) on which OSPF runs and associate the area ID (5).
(config-router)#network 36.0.0.0/8 area 5	Define the network (36.0.0.0/8) on which OSPF runs and associate the area ID (5).
(config-router)#exit	Exit the router configure mode.
(config)#rsvp-path pb1	Enter the path mode for rsvp pb1.
(config-path)#36.0.0.2 strict	Configure this explicit route path as a strict hop.
(config-path)#66.1.1.3 strict	Configure this explicit route path as a strict hop.
(config-path)#29.29.29.29 loose	Configure this explicit route path as a loose hop.
(config)#exit	Exit the path mode.
(config)#rsvp-path pt1	Enter the path mode for rsvp pt1.
(config-path)#16.1.1.2 strict	Configure this explicit route path as a strict hop.
(config-path)#56.1.1.4 strict	Configure this explicit route path as a strict hop.
(config-path)#30.30.30.30 loose	Configure this explicit route path as a loose hop.
(config)#exit	Exit the path mode.
(config)#rsvp-path psec	Enter the path mode for rsvp psec.
(config-path)#36.0.0.2 strict	Configure this explicit route path as a strict hop.
(config-path)#46.1.1.3 strict	Configure this explicit route path as a strict hop.
(config)#exit	Exit the path mode.
(config)#rsvp-path pt0	Enter the path mode for rsvp plink.
(config-path)#16.1.1.2 strict	Configure this explicit route path as a strict hop.
(config)#exit	Exit the path mode.

PE2

#configure terminal	Enter configure mode.

(config)#mpls class-type ct0 class0	Define class type names, and enable class types.
(config)#mpls te-class te0 class0 0	
(config)#mpls te-class te1 class0 1	
(config)#mpls te-class te2 class0 2	
(config)#mpls te-class te3 class0 3	
(config)#mpls te-class te4 class0 4	
(config)#mpls te-class te5 class0 5	
(config)#mpls te-class te6 class0 6	
(config)#mpls te-class te7 class0 7	
(config)#interface lo	Enter interface mode.
(config-if)#ip address 29.29.29.29/32 secondary	Set a secondary IP address of the interface to 29.29.29.29/32.
(config-if)#no shutdown	Administratively shut down the interface.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#bandwidth 100m	Reserve bandwidth, and configure the bandwidth constraint for each class type on the eth1 interface.
(config-if)#reservable-bandwidth 100m	Set the reservable bandwidth parameter
(config-if)#bandwidth-constraint class0 100m	Set the bandwidth constraint parameter
(config-if)#ip address 36.0.0.2/8	Set an IP address of the interface to 36.0.0.2/8.
(config-if)#no shutdown	Administratively shut down the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#bandwidth 100m	Reserve bandwidth, and configure the bandwidth constraint for each class type on the eth1 interface.
(config-if)#reservable-bandwidth 100m	Set the reservable bandwidth parameter
(config-if)#bandwidth-constraint class0 100m	Set the bandwidth constraint parameter
(config-if)#ip address 14.0.0.2/8	Set an IP address of the interface to 14.0.0.2/8.
(config-if)#no shutdown	Administratively shut down the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth3	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#bandwidth 100m	Reserve bandwidth, and configure the bandwidth constraint for each class type on the eth1 interface.
(config-if)#reservable-bandwidth 100m	Set the reservable bandwidth parameter
(config-if)#bandwidth-constraint class0 100m	Set the bandwidth constraint parameter
(config-if)#ip address 66.0.0.3/8	Set an IP address of the interface to 66.0.0.3/8
(config-if)#no shutdown	Administratively shut down the interface.

(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit the Interface mode.
(config)#router ospf	Enter the router configure mode for ospf.
(config-router)#timers spf exp 500 50000	Set the routing timer for a SPF timer to use exponential back off delay.
(config-router)#network 14.0.0.0/8 area 5	Define the network (14.0.0.0/8) on which OSPF runs and associate the area ID (5).
(config-router)#network 16.0.0.0/8 area 5	Define the network (16.0.0.0/8) on which OSPF runs and associate the area ID (5).
(config-router)#network 29.29.29.29/32 area 5	Define the network (29.29.29.29/32) on which OSPF runs and associate the area ID (5).
(config-router)#network 66.0.0.0/8 area 5	Define the network (66.0.0.0/8) on which OSPF runs and associate the area ID (5).
(config-router)#exit	Exit the router configure mode.
(config)#rsvp-path pb1	Enter the path mode for rsvp pb1.
(config-path)#16.0.0.1 strict	Configure this explicit route path as a strict hop.
(config-path)#36.0.0.2 strict	Configure this explicit route path as a strict hop.
(config)#exit	Exit the path mode.
(config)#rsvp-path pt1	Enter the path mode for rsvp pt1.
(config-path)#16.0.0.1 strict	Configure this explicit route path as a strict hop.
(config-path)#36.0.0.2 strict	Configure this explicit route path as a strict hop.
(config)#exit	Exit the path mode.
(config)#rsvp-bypass bpe2	Enter the bypass mode for rsvp bpe2.
(config-bypass)#path pb1	Specify a path to be used.
(config-bypass)#label-record	Specify that record labels are exchanged by all peers.
(config-bypass)#bandwidth 100m	Specify the maximum bandwidth (in bits per second) to be used by this interface.
(config-bypass)#from 29.29.29.29	Specify the egress (source point)
(config-bypass)#to 28.28.28.28	Specify the egress (destination point)
(config-bypass)#exit	Exit the path mode.

R1

#configure terminal	Enter configure mode.
(config)#mpls class-type ct0 class0	Define class type names, and enable class types.
(config)#mpls te-class te0 class0 0	
(config)#mpls te-class te1 class0 1	
(config)#mpls te-class te2 class0 2	
(config)#mpls te-class te3 class0 3	
(config)#mpls te-class te4 class0 4	
(config)#mpls te-class te5 class0 5	
(config)#mpls te-class te6 class0 6	
(config)#mpls te-class te7 class0 7	

(config)#interface lo	Enter interface mode.
(config-if)#ip address 28.28.28.28/32 secondary	Set a secondary IP address of the interface to 28.28.28.28/32.
(config-if)#no shutdown	Administratively shut down the interface.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#bandwidth 100m	Reserve bandwidth, and configure the bandwidth constraint for each class type on the eth1 interface.
(config-if)#reservable-bandwidth 100m	Set the reservable bandwidth parameter
(config-if)#bandwidth-constraint class0 100m	Set the bandwidth constraint parameter
(config-if)#ip address 36.0.0.2/8	Set an IP address of the interface to 36.0.0.2/8.
(config-if)#no shutdown	Administratively shut down the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#bandwidth 100m	Reserve bandwidth, and configure the bandwidth constraint for each class type on the eth1 interface.
(config-if)#reservable-bandwidth 100m	Set the reservable bandwidth parameter
(config-if)#bandwidth-constraint class0 100m	Set the bandwidth constraint parameter
(config-if)#ip address 66.0.0.2/8	Set an IP address of the interface to 66.0.0.2/8.
(config-if)#no shutdown	Administratively shut down the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth3	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#bandwidth 100m	Reserve bandwidth, and configure the bandwidth constraint for each class type on the eth1 interface.
(config-if)#reservable-bandwidth 100m	Set the reservable bandwidth parameter
(config-if)#bandwidth-constraint class0 100m	Set the bandwidth constraint parameter
(config-if)#ip address 46.0.0.1/8	Set an IP address of the interface to 46.0.0.1/8
(config-if)#no shutdown	Administratively shut down the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit the Interface mode.
(config)#router ospf	Enter the router configure mode for ospf.
(config-router)#timers spf exp 500 50000	Set the routing timer for a SPF timer to use exponential back off delay.
(config-router)#network 28.28.28.28/32 area 5 area 5	Define the network (28.28.28.28/32 area 5) on which OSPF runs and associate the area ID (5).
(config-router)#network 36.0.0.0/8 area 5	Define the network (36.0.0.0/8) on which OSPF runs and associate the area ID (5).

(config-router)#network 46.0.0.0/8 area 5 area 5	Define the network (46.0.0.0/8) on which OSPF runs and associate the area ID (5).
(config-router)#network 66.0.0.0/8 area 5	Define the network (66.0.0.0/8) on which OSPF runs and associate the area ID (5).
(config-router)#exit	Exit the router configure mode.

PE3

#configure terminal	Enter configure mode.
(config)#mpls class-type ct0 class0	Define class type names, and enable class types.
(config)#mpls te-class te0 class0 0	
(config)#mpls te-class te1 class0 1	
(config)#mpls te-class te2 class0 2	
(config)#mpls te-class te3 class0 3	
(config)#mpls te-class te4 class0 4	
(config)#mpls te-class te5 class0 5	
(config)#mpls te-class te6 class0 6	
(config)#mpls te-class te7 class0 7	
(config)#interface lo	Enter interface mode.
(config-if)#ip address 30.30.30.30/32 secondary	Set a secondary IP address of the interface to 30.30.30.30/32.
(config-if)#ipv6 address ::1/128	Set an IPv6 address of the interface to ::1/128.
(config-if)#no shutdown	Administratively shut down the interface.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#bandwidth 100m	Reserve bandwidth, and configure the bandwidth constraint for each class type on the eth1 interface.
(config-if)#reservable-bandwidth 100m	Set the reservable bandwidth parameter
(config-if)#bandwidth-constraint class0 100m	Set the bandwidth constraint parameter
(config-if)#ip address 46.0.0.3/8	Set an IP address of the interface to 46.0.0.3/8.
(config-if)#no shutdown	Administratively shut down the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#shutdown	Administratively shut down the interface.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth3	Enter interface mode.
(config-if)#shutdown	Administratively shut down the interface.
(config-if)#exit	Exit the Interface mode.
(config)#router ospf	Enter the router configure mode for ospf.
(config-router)#timers spf exp 500 50000	Set the routing timer for a SPF timer to use exponential back off delay.

(config-router)#network 30.30.30.30/32 area 5	Define the network (30.30.30.30/32) on which OSPF runs and associate the area ID (5).
(config-router)#network 46.0.0.0/8 area 5 area 5	Define the network (46.0.0.0/8) on which OSPF runs and associate the area ID (5).
(config-router)#exit	Exit the router configure mode.
(config)#rsvp-path pb1	Enter the path mode for rsvp pb1.
(config-path)#16.0.0.1 strict	Configure this explicit route path as a strict hop.
(config-path)#36.0.0.2 strict	Configure this explicit route path as a strict hop.
(config)#exit	Exit the path mode.

Validation for PE0

```
PE0#show rsvp session
Ingress RSVP:
To              From            State Pri Rt Style Labelin Labelout LSPName
DSType
30.30.30.30     26.26.26.26     Up    Yes  1  1 SE       -    52480 t1
DEFAULT
Total 1 displayed, Up 1, Down 0

PE0#show mpls forwarding-table
Codes: > - selected FTN, p - stale FTN, B - BGP FTN, K - CLI FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN

Code    FEC                 Tunnel-id   FTN-ID    Pri  Nexthop          Out-
Label    Out-Intf     LSP-Type
R>     30.30.30.30/32     101       1       Yes  14.0.0.2       52480
eth2          LSP_DEFAULT

PE0#show mpls ftn-table
 Primary FTN entry with FEC: 30.30.30.30/32, id: 1, row status: Active
  Owner: RSVP, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 101,   Protected LSP id: 101, QoS Resource id: 4, Description: t1
    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: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
   Out-segment with ix: 1, owner: RSVP, out intf: eth2, out label: 52480
    Nexthop addr: 14.0.0.2, cross connect ix: 1, op code: Push
```

Show output for PE2

```
PE2#show rsvp session
Ingress RSVP:
To              From            State Pri Rt Style Labelin Labelout LSPName
DSType
28.28.28.28     29.29.29.29     Up    Yes  1  1 SE       -    52480 bpe2
DEFAULT
Total 1 displayed, Up 1, Down 0.

Transit RSVP:
To              From            State Pri Rt Style Labelin Labelout LSPName
DSType
30.30.30.30     26.26.26.26     Up    Yes  1  1 SE   52480    52480 t1
ELSP_CON
```

```
Total 1 displayed, Up 1, Down 0

PE2#show mpls ilm-table
Codes: > - selected ILM, K - CLI ILM

Code  In-Label  Out-Label  In-Intf  Out-Intf  Nexthop        FEC
ILM-ID       LSP-Type
   >  52480    52480      eth2     eth3      66.0.0.2        30.30.30.30/32
3           ELSP_CONFIG
PE2#show mpls ftn-table
 Primary FTN entry with FEC: 28.28.28.28/32, id: 1, row status: Active
  Owner: RSVP, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 101,   Protected LSP id: 101, QoS Resource id: 2, Description:
bpe2
    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: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
   Out-segment with ix: 1, owner: RSVP, out intf: eth1, out label: 52480
    Nexthop addr: 16.0.0.1, cross connect ix: 1, op code: Push
```

Validation for R1

```
R1#show rsvp session
Transit RSVP:
To              From            State Pri Rt Style Labelin Labelout LSPName
DSType
30.30.30.30     26.26.26.26     Up    Yes  1  1 SE   52480        3 t1
ELSP_CON
Total 1 displayed, Up 1, Down 0.

Egress RSVP:
To              From            State Pri Rt Style Labelin Labelout LSPName
DSType
28.28.28.28     29.29.29.29     Up    Yes  1  1 SE       3        - bpe2
ELSP_CON
Total 1 displayed, Up 1, Down 0.

R1#show mpls ilm-table
Codes: > - selected ILM, K - CLI ILM
Code  In-Label  Out-Label  In-Intf  Out-Intf  Nexthop        FEC
ILM-ID       LSP-Type
   >  52480    3          eth2     eth3      46.0.0.3        30.30.30.30/32
3           ELSP_CONFIG
R1#show mpls ftn-table
```

Validation for PE0

```
PE3#show rsvp session
Egress RSVP:
To              From            State Pri Rt Style Labelin Labelout LSPName
DSType
30.30.30.30     26.26.26.26     Up    Yes  1  1 SE       3        - t1
ELSP_CON
Total 1 displayed, Up 1, Down 0.

PE3#s
show         start-shell
PE3#show mpls ilm-table
PE3#show mpls ftn-table
```

```
PE3#
```

Validation for PE1

```
PE1>enable
PE1#show rsvp session
Transit RSVP:
To              From            State Pri Rt Style Labelin Labelout LSPName
DSType
28.28.28.28     29.29.29.29     Up    Yes  1  1 SE   52480        3 bpe2
ELSP_CON
Total 1 displayed, Up 1, Down 0.

PE1#show mpls ilm-table
Codes: > - selected ILM, K - CLI ILM

Code  In-Label  Out-Label  In-Intf  Out-Intf  Nexthop         FEC
ILM-ID        LSP-Type
   >  52480     3          eth2     eth3      36.0.0.2        28.28.28.28/32
1             ELSP_CONFIG
```

Validation for PE0

```
PE3#show rsvp session
Egress RSVP:
To              From            State Pri Rt Style Labelin Labelout LSPName
DSType
30.30.30.30     26.26.26.26     Up    Yes  1  1 SE       3        - t1
ELSP_CON
Total 1 displayed, Up 1, Down 0.
```

Integrated Service Configuration

This Section contains configurations for enabling policer on Resource Reservation Protocol - Traffic Engineering (RSVP-TE) trunk, this will make sure that traffic will not exceed the bandwidth more than that of reserved on that trunk

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. Configure Diffserv-TE for builds which support them
2. Enable label-switching and RSVP-TE on all participating interfaces.
3. Configure a trunk on the ingress router to use the best available IGP path.
4. Configure bandwidth that needs to be reserved on this trunk
5. Enable primary policer

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.

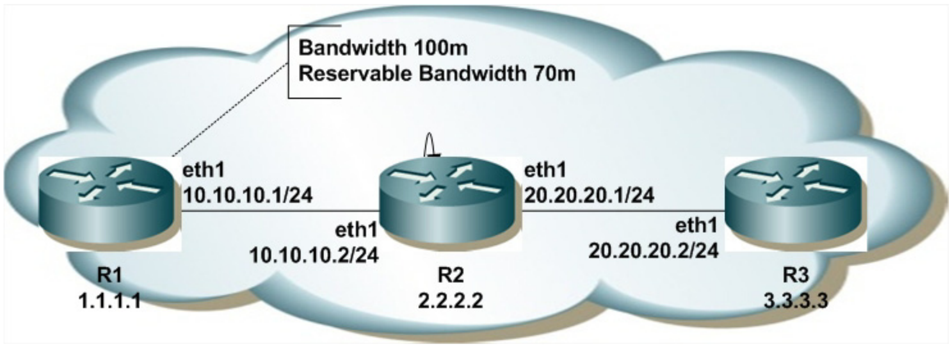


Figure 4-9: Topology for Minimal Configuration

R1 - NSM

`#configure terminal`	Enter configure mode.
`(config)#interface eth0`	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 `eth0`.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#bandwidth 100m`	Specify the maximum bandwidth (in bits per second) to be used by this interface.
`(config-if)#reservable-bandwidth 70m`	Specify the maximum reservable bandwidth per interface.
`(config-if)#exit`	Exit interface mode.

R1 - RSVP-TE

`#configure terminal`	Enter configure mode.
`(config)#rsvp-path myPath`	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 `Trunk` mode.
`(config-trunk)#primary path myPath`	Specify an RSVP path to be used.
`(config-trunk)#primary bandwidth 10m`	Reserve the bandwidth in bits per second for the current trunk `T1`.
`(config-trunk)#to 192.168.0.90`	Specify the IPv4 egress (destination point) for the LSP.
`(config-trunk)#primary policer`	Enable policer on the trunk, this will be programed in Hardware of Ingress LER.
`(config-trunk)#exit`	Exit `Trunk` mode.

Validation Command

```
#show rsvp session
Ingress RSVP:
To               From             State Pri  Rt  Style   Labelin  Labelout
LSPName      DSType
192.168.0.90    192.168.0.63    Up   Yes  1   1 SE      -    52480    T1
DEFAULT
Total 1 displayed, Up 1, Down 0.

#show rsvp session detail
Ingress (Primary)
192.168.0.90
  From: 192.168.0.63, LSPstate: Up, LSPname: T1
  Ingress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  IGP-Shortcut: Disabled, LSP metric: 3
  Label in: -,  Label out:    52480
  Tspec rate: 10m, Fspec rate: 10m
  Policer: Configured and installed in hardware
  Tunnel Id: 5001, LSP Id: 101, Ext-Tunnel Id: 192.168.0.63
  Downstream: 10.10.23.60, eth1
  Path refresh: 30 seconds (RR enabled) (due in 29 seconds)
  Resv lifetime: 157 seconds (due in 120 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: mypath (in use)
  Configured Explicit Route Detail :
  10.10.23.60/32 strict
  10.10.21.90/32 loose
  Session Explicit Route Detail :
   10.10.23.60/32 strict
   10.10.21.90/32 strict
  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
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
```

When Policer not installed in hardware due to session failure

```
#show rsvp session detail
Ingress (Primary)
192.168.0.90
  From: 192.168.0.63, LSPstate: Up, LSPname: T1
  Ingress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  IGP-Shortcut: Disabled, LSP metric: 3
  Label in: -,  Label out:    52480
  Tspec rate: 10m, Fspec rate: 10m
```

```
Policer: Configured but not installed in hardware
Tunnel Id: 5001, LSP Id: 101, Ext-Tunnel Id: 192.168.0.63
Downstream: 10.10.23.60, eth1
Path refresh: 30 seconds (RR enabled) (due in 29 seconds)
Resv lifetime: 157 seconds (due in 120 seconds)
Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Configured Path: mypath (in use)
Configured Explicit Route Detail :
10.10.23.60/32 strict
10.10.21.90/32 loose
Session Explicit Route Detail :
 10.10.23.60/32 strict
 10.10.21.90/32 strict
 Record route: <self>  ...incomplete
Style: Shared Explicit Filter
Traffic type: N/A
Minimum Path MTU: N/A
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
```

CHAPTER 5 RSVP-TE Point-to-Multipoint LSP

This chapter contains configurations for Resource Reservation Protocol - Traffic Engineering (RSVP-TE) Point-to-Multipoint (P2MP) LSP. It also has a brief overview of ZebOS-XP RSVP-TE P2MP basic concepts.

Overview

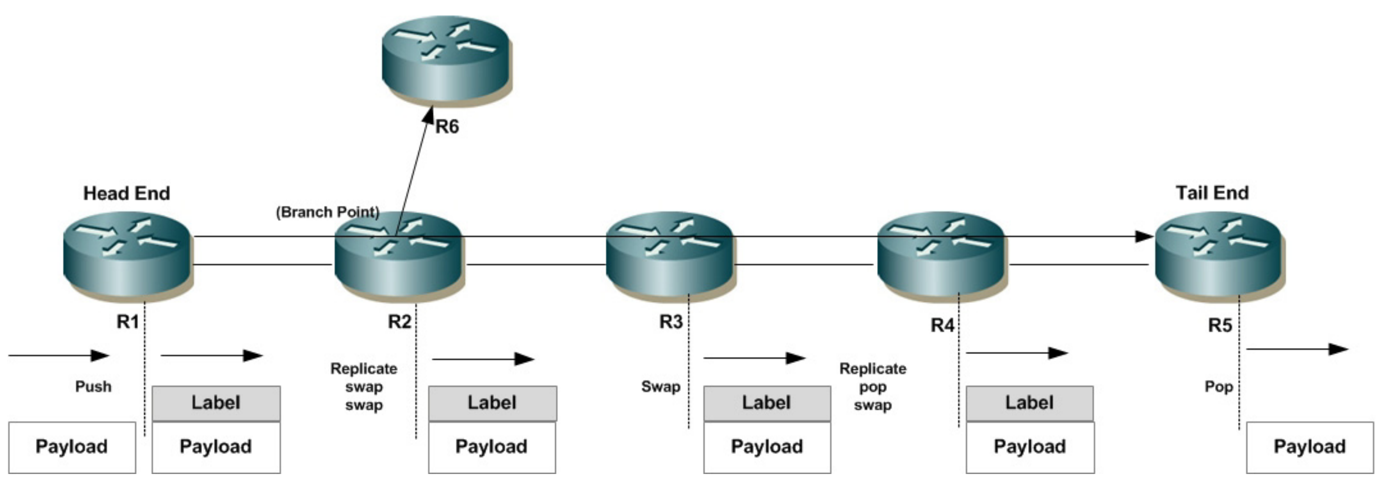
Existing MPLS traffic engineering (MPLS-TE) allows for strict QoS guarantees, resource optimization, and fast failure recovery, but it is limited to point-to-point (P2P) LSPs. In addition, MPLS is well-suited to Traffic Engineering (TE).

Currently many service providers use native IP multicast in order to provide IPTV broadcasting service, contents delivery service, etc. However IP multicast has a few issues which hamper its deployment at the core:-

- No traffic engineering capabilities including lack of QoS guarantees and path selection flexibility both of which are critical for multicast applications
- Re-convergence time in case of failures is in the order of several seconds or more
- Does not scale well Requires maintenance of large no. of states across the core.

Standard MPLS-TE provides explicit path setting capabilities along with off-line computation, bandwidth guarantee, and multiple disjoint paths for stream redundancy in Video Broadcasting, less multicast state in the core network. There is a desire to support point-to-multipoint (P2MP) services using traffic-engineered LSPs, in order to deliver data from a single source to one or more receivers.

A P2MP TE LSP is a TE LSP with a single ingress LSR and one or more egress LSRs, and is unidirectional. Apart from traversing the regular Transit LSRs that connect a single in-segment to a single out-segment in conventional MPLS, P2MP LSPs also traverse Branch LSRs, which connect a single in-segment to multiple out-segments and Bud LSRs, both of which consume the traffic and also connect to one or more out-segments, thereby facilitating P2MP operation.



P2MP services may be supported with any combination of P2P and P2MP LSPs depending on the degree of optimization required within the network, and such LSPs may be traffic-engineered. In addition, multipoint to-multipoint (MP2MP) services, which deliver data from more than one source to one or more receivers, can also be supported with a combination of P2P and P2MP LSPs.

Definitions

Some P2MP terms are defined below.

P2MP Tunnels

A P2MP TE Tunnel comprises one or more P2MP LSPs. A P2MP TE Tunnel is identified by a P2MP SESSION object. This object contains the identifier of the P2MP Session, which includes the P2MP Identifier (P2MP ID), a tunnel Identifier (Tunnel ID), and an extended tunnel identifier (Extended Tunnel ID). The P2MP ID is a four-octet number and is unique within the scope of the ingress LSR.

The <P2MP ID, Tunnel ID, Extended Tunnel ID> tuple provides an identifier for the set of destinations of the P2MP TE Tunnel.

P2MP LSP

A P2MP LSP is identified by the combination of the P2MP ID, Tunnel ID, and Extended Tunnel ID that are part of the P2MP SESSION object, and the tunnel sender address and LSP ID fields of the P2MP SENDER_TEMPLATE object.

S2L Sub-LSP

A P2MP LSP is constituted of one or more Source-To-Leaf (S2L) sub-LSPs.

Source Node

A P2MP Source Node is the Ingress Node or Tunnel Head-End from where a P2MP S2L Sub-LSP is originated.

Leaf Node

A P2MP Leaf Node is the Egress Node or Tunnel End-Point where a P2MP S2L Sub-LSP is terminated.

Branch Node

A branch node replicates data flows and forwards them to multiple next-hop LSRs.

Transit Node

A transit node is any node which forwards traffic (just like a normal P2P LSP transit node).

Bud Node

A bud node is a combination of a leaf node and a branch/transit node. It replicates data traffic and both pass it up to local endpoints and forward it to next-hop LSRs.

Topology 1

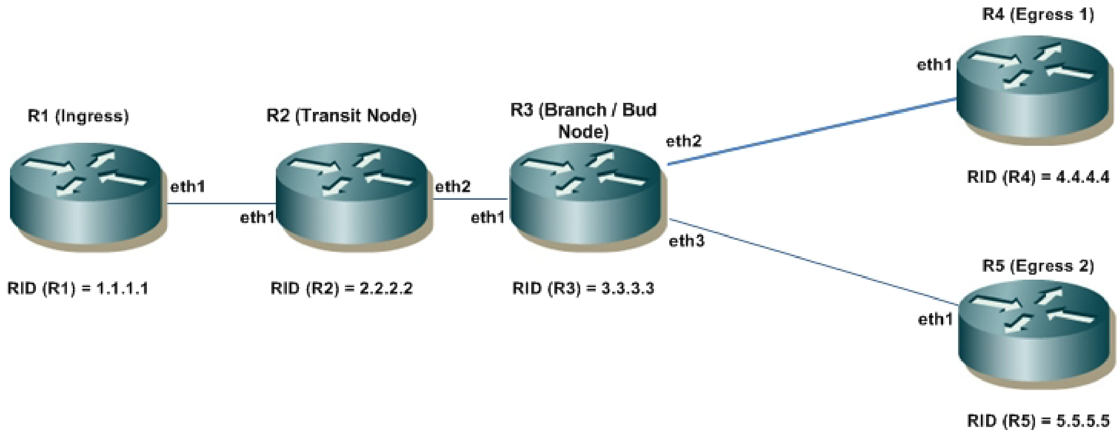


Figure 5-1: Topology 1

Node-Interface-IP Address Matrix

Node Name	Interface Name	IP Address
R1	eth1	10.1.1.1/24
R2	eth1	10.1.1.2/24
	eth2	20.1.1.1/24
R3	eth1	20.1.1.2/24
	eth2	30.1.1.1/24
	eth3	40.1.1.1/24
R4	eth1	30.1.1.2/24
R5	eth1	40.1.1.2/24

Enable Label Switching and RSVP-TE

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 next-hop available in its IP routing table.

R1 Ingress Node

NSM

`#configure terminal`	Enter Configure Mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 1.1.1.1/32`	Set the IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#ip address 10.1.1.1/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface eth1.
`(config-if)#exit`	Exit interface mode.

RSVP-TE

`(config)#router rsvp`	Enter Configure Router mode.
`(config-router)#exit`	Exit Router mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#exit`	Exit interface mode.

R2 Transit Node

NSM

`#configure terminal`	Enter Configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 2.2.2.2/32`	Set the IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#ip address 10.1.1.2/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface eth1.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode.

(config-if)#ip address 20.1.1.1/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#exit	Exit interface mode.

RSVP-TE

(config)#router rsvp	Enter Configure Router mode.
(config)#no refresh-reduction	Disable refresh reduction; it is enabled by default.
(config-router)#exit	Exit Router mode.
(config)#interface eth1	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.

R3 Branch/Bud Node

NSM

#configure terminal	Enter Configure Mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 3.3.3.3/32	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface lo.
(config-if)#exit	Exit interface mode.
(config)#interface eth1	Enter interface mode.
(config-if)#ip address 20.1.1.2/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#ip address 30.1.1.1/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#exit	Exit interface mode.
(config)#interface eth3	Enter interface mode.
(config-if)#ip address 40.1.1.1/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface eth3.
(config-if)#exit	Exit interface mode.

RSVP-TE

(config)#router rsvp	Enter Configure Router mode.
(config)#no refresh-reduction	Disable the refresh reduction; it is enabled by default.
(config-router)#exit	Exit Router mode.

(config)#interface eth1	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface eth3	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.

R4 Egress1 Node

NSM

#configure terminal	Enter Configure Mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 4.4.4.4/32	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface lo.
(config-if)#exit	Exit interface mode.
(config)#interface eth1	Enter interface mode.
(config-if)#ip address 30.1.1.2/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#exit	Exit interface mode.

RSVP-TE

(config)#router rsvp	Enter Configure Router mode.
(config)#no refresh-reduction	Disable the refresh reduction; it is enabled by default.
(config-router)#exit	Exit Router mode/
(config)#interface eth1	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.

R5 Egress2 Node

NSM

#configure terminal	Enter Configure Mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 5.5.5.5/32	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface lo.
(config-if)#exit	Exit interface mode.
(config)#interface eth1	Enter interface mode.

`(config-if)#ip address 40.1.1.2/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface eth1.
`(config-if)#exit`	Exit interface mode.

RSVP-TE

`(config)#router rsvp`	Enter Configure Router mode.
`(config)#no refresh-reduction`	Disable the refresh reduction; it is enabled by default.
`(config-router)#exit`	Exit Router mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#exit`	Exit interface mode.

R1 Ingress Node

OSPF

`#configure terminal`	Enter configure mode.
`(config)#router ospf 100`	Configure the Routing process and assign Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#network 1.1.1.1/32 area 0`	Configure the loopback interface address to be advertised through OSPF.
`(config-router)#network 10.1.1.0/24 area 0`	Configure the eth1 interface network address to be advertised through OSPF.
`(config-router)#exit`	Exit Router mode.

R2 Transit Node

OSPF

`#configure terminal`	Enter configure mode.
`(config)#router ospf 100`	Configure the Routing process and assign the Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#network 2.2.2.2/32 area 0`	Configure the loopback interface address to be advertised through OSPF.
`(config-router)#network 10.1.1.0/24 area 0`	Configure the eth1 interface network address to be advertised through OSPF.
`(config-router)#network 20.1.1.0/24 area 0`	Configure the eth2 interface network address to be advertised through OSPF.
`(config-router)#exit`	Exit Router mode.

R3 Branch/Bud Node

OSPF

`(config)#router ospf 100`	Configure the Routing process and assign the Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#network 3.3.3.3/32 area 0`	Configure the loopback interface address to be advertised through OSPF.
`(config-router)#network 20.1.1.0/24 area 0`	Configure the eth1 interface network address to be advertised through OSPF.
`(config-router)#network 30.1.1.0/24 area 0`	Configure the eth2 interface network address to be advertised through OSPF.
`(config-router)#network 40.1.1.0/24 area 0`	Configure the eth3 interface network address to be advertised through OSPF.
`(config-router)#exit`	Exit Router mode.

R4 Egress1 Node

OSPF

`#configure terminal`	Enter configure mode.
`(config)#router ospf 100`	Configure the Routing process and assign the Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#network 4.4.4.4/32 area 0`	Configure the loopback interface address to be advertised through OSPF.
`(config-router)#network 30.1.1.0/24 area 0`	Configure the eth1 interface network address to be advertised through OSPF.
`(config-router)#exit`	Exit Router mode.

R5 Egress2 Node

OSPF

`#configure terminal`	Enter configure mode.
`(config)#router ospf 100`	Configure the Routing process and assign the Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#network 5.5.5.5/32 area 0`	Configure the loopback interface address to be advertised through OSPF.
`(config-router)#network 40.1.1.0/24 area 0`	Configure the eth1 interface network address to be advertised through OSPF.
`(config-router)#exit`	Exit Router mode.

Validation

show rsvp interface

Establish Trunk with CSPF Disabled

In ZebOS-XP, 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, a P2MP LSP is established only along the path specified by the network administrator.

Note: This example is based on the assumption that a minimal configuration exists on all participating routers.

R1 Ingress Node

RSVP-TE

`#configure terminal`	Enter configure mode.
`(config)#rsvp-trunk T1 ipv4 p2mp`	Create an RSVP trunk T1 and enter the Trunk mode.
`(config-p2mp-trunk)#from 1.1.1.1`	Configure the source loopback address of the Trunk.
`(config-p2mp-trunk)#ext-tunnel-id 1.1.1.1`	Configure the extended tunnel id as source loopback address of the Trunk.
`(config-p2mp-trunk)#primary-lsp`	Create a Primary P2MP LSP and enter the LSP mode.
`(config-p2mp-lsp)#destination 4.4.4.4 no-cspf`	Configure a P2MP destination for R4 (Egress1) and specify no-cspf since CSPF is enabled by default.
`(config-p2mp-lsp)#destination 5.5.5.5 no-cspf`	Configure a P2MP destination for R5 (Egress2) and specify no-cspf since CSPF is enabled by default.
`(config-p2mp-lsp)#exit`	Exit P2MP LSP mode.
`(config-p2mp-trunk)#exit`	Exit P2MP Trunk mode.

Establish Trunk Using CSPF

The RSVP P2MP 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 ZebOS-XP, 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.

R2 Ingress Node

RSVP-TE

`#configure terminal`	Enter configure mode.
`(config)#rsvp-trunk T1 ipv4 p2mp`	Create an RSVP trunk T1 and enter the Trunk mode.
`(config-p2mp-trunk)#from 1.1.1.1`	Configure the source loopback address of the Trunk.
`(config-p2mp-trunk)#ext-tunnel-id 1.1.1.1`	Configure the extended tunnel ID as source loopback address of the Trunk.
`(config-p2mp-trunk)#filter (fixed | shared-explicit)`	Configure Reservation Style as either Fixed Filter or Shared Explicit.
`(config-p2mp-trunk)#primary-lsp`	Create a Primary P2MP LSP and enter the LSP mode.

(config-p2mp-lsp)#destination 4.4.4.4 cspf	Configure a P2MP destination for R4 (Egress1) with or without specifying cspf since CSPF is enabled by default.
(config-p2mp-lsp)#destination 5.5.5.5 cspf	Configure a P2MP destination for R5 (Egress2) with or without specifying cspf since CSPF is enabled by default.
(config-p2mp-lsp)#exit	Exit P2MP LSP mode.
(config-p2mp-trunk)#exit	Exit P2MP Trunk mode.

Configure Properties of a P2MP LSP

R1 Ingress Node

#configure terminal	Enter configure mode.
(config)#rsvp-trunk T1 ipv4 p2mp	Create an RSVP trunk T1 and enter the Trunk mode.
(config-p2mp-trunk)#primary-lsp	Create a Primary P2MP LSP and enter the LSP mode.
(config-p2mp-lsp)#setup-priority 7	Configure the numerical value of setup priority greater than or equal to the numerical value of hold priority for a P2MP LSP to get established.
(config-p2mp-lsp)#hold-priority 6	Configure the numerical value of hold priority less than or equal to the numerical value of setup priority for a P2MP LSP to get established.
(config-p2mp-lsp)#bandwidth 100m	Configure bandwidth for the P2MP LSP.
(config-p2mp-lsp)#route-record	Enable Record Route for the P2MP LSP.
(config-p2mp-lsp)#label-record	Enable Label Route for the P2MP LSP.
(config-p2mp-lsp)#retry-timer 30	Configure retry timer value.
(config-p2mp-lsp)#retry-limit 100	Configure retry limit value.
(config-p2mp-lsp)#hop-limit 50	Configure hop limit value.
(config-p2mp-lsp)#exit	Exit P2MP LSP mode.
(config-p2mp-trunk)#exit	Exit P2MP Trunk mode.

Note: The commands for the primary and secondary P2MP LSPs, such as `traffic`, `dste class`, and `pack-affinity` are the same as those used for P2P LSPs.

Establish 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 routes in between. In this example, since R4 is defined as a loose hop, R2 can use R3 as an intermediate hop to reach R4. However, if it was a strict hop, then R2 would have to use interface `eth2` to reach R4 directly.

Note: This example is based on the assumption that a minimal configuration exists on all participating routers.

Topology 2

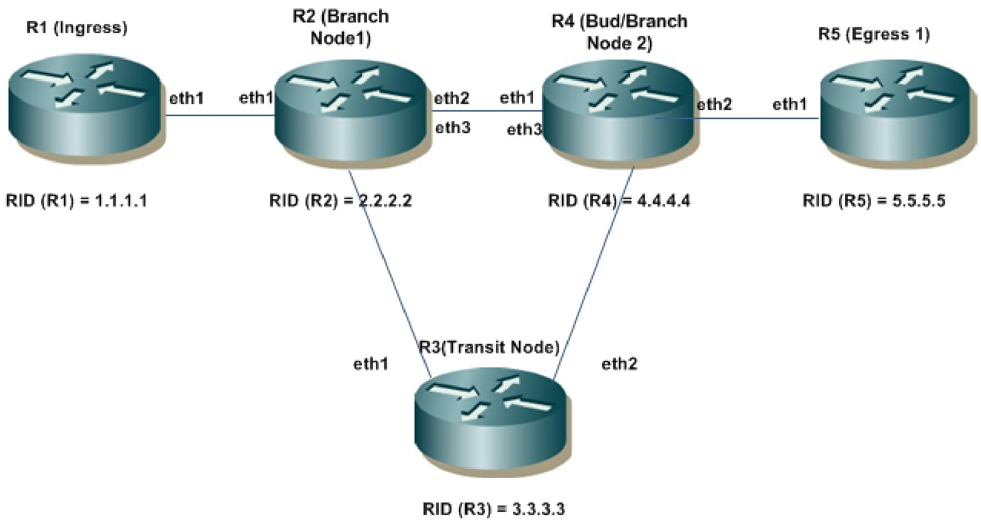


Figure 5-2: P2MP Topology 2

Node-Interface-IP Address Matrix

Node Name	Interface Name	IP Address
R1	eth1	10.1.1.1/24
R2	eth1	10.1.1.2/24
	eth2	20.1.1.1/24
	eth3	30.1.1.1/24
R3	eth1	30.1.1.2/24
	eth2	40.1.1.1/24
R4	eth1	20.1.1.2/24
	eth2	50.1.1.1/24
	eth3	40.1.1.2/24
R5	eth1	50.1.1.2/24

R1 (Ingress Node)

RSVP-TE

`#configure terminal`	Enter configure mode.
`(config)#rsvp-path P1`	Create an RSVP Path P1 and enter the Path mode.

(config-path)#10.1.1.2 strict	Configure the explicit route path eth1 of R2 as a strict hop.
(config-path)#20.1.1.2 loose	Configure the explicit route path eth1 of R4 as a loose hop.
(config-path)#exit	Exit Path Mode.
(config)#rsvp-trunk T1 ipv4 p2mp	Create an RSVP trunk T1 and enter the Trunk mode.
(config-p2mp-trunk)#primary-lsp	Create a Primary P2MP LSP and enter the LSP mode.
(config-p2mp-lsp)#destination 4.4.4.4 path P1 no-cspf	Configure a P2MP destination for R4 (Bud) with specifying path P1 and no-cspf since CSPF is enabled by default.
(config-p2mp-lsp)#destination 5.5.5.5 path P1 cspf	Configure a P2MP destination for R5 (Egress1) and specify path P1 and cspf.
(config-p2mp-lsp)#exit	Exit P2MP LSP mode.
(config-p2mp-trunk)#exit	Exit P2MP Trunk mode.

Configure Fast Reroute Properties

R1 Ingress Node

RSVP-TE

#configure terminal	Enter configure mode.
(config)#rsvp-trunk T1 ipv4 p2mp	Create an RSVP trunk T1 and enter the Trunk mode.
(config-p2mp-trunk)#primary-lsp	Create a Primary P2MP LSP and enter the LSP mode.
(config-p2mp-lsp)#fast-reroute protection facility	Configure FRR protection facility on the LSP.
(config-p2mp-lsp)#fast-reroute bandwidth 10m	Configure the bandwidth for FRR on the LSP.
(config-p2mp-lsp)#fast-reroute node-protection	Enable Node Protection FRR for the LSP.
(config-p2mp-lsp)#exit	Exit P2MP LSP mode.
(config-p2mp-trunk)#exit	Exit P2MP Trunk mode.

Common Global and Interface Commands

The following are the common global and interface configurations required for each RSVPTE P2MP node for establishing basic P2MP LSP. These commands are common to RSVPTE P2P as well and have to be configured at each node and for each RSVPTE supported interface.

R1 Ingress Node

RSVP-TE

#configure terminal	Enter configure mode.
(config)#mpls class-type ct0 default	Define class type names, and enable class types.

`(config)#mpls te-class te0 default 0`	Define the DiffServ TE class, class type name, and preemption priority.
`(config)#mpls te-class te1 default 1`	
`(config)#mpls te-class te2 default 2`	
`(config)#mpls te-class te3 default 3`	
`(config)#mpls te-class te4 default 4`	
`(config)#mpls te-class te5 default 5`	
`(config)#mpls te-class te6 default 6`	
`(config)#mpls te-class te7 default 7`	
`(config)#interface eth1`	Enter interface mode.
`(config-if)#bandwidth 100m`	Reserve bandwidth, and configure the bandwidth constraint for each class type on the eth1 interface.
`(config-if)#reservable-bandwidth 100m`	Configure reservable bandwidth.
`(config-if)#bandwidth-constraint default 100m`	Configure default bandwidth constraint.t
`(config-if)#exit`	Exit interface mode.

Note: Admin group affiliation per interface command is same as for an RSVP-TE P2P LSP.

Validation

Use the following RSVP-TE commands to display the results of the configurations covered in this chapter. These commands display brief, summary P2MP Trunk, Session, and Sub-LSP information.

```
#show rsvp p2mp-session
=====================================================================
TunnelName: ABCD
Tunnel-ID : 100      Ext-Tunnel-ID: 1.1.1.1         P2MP-ID: 10
#LSP(s)   : 2
 --------------------------------------------------------------------
 LSP-ID   : 65530    LSP-Type: Primary              State   : Up
 LSP-Role : Ingress  Sub-Role: No-Branch         #SubLSP: 65535
 --------------------------------------------------------------------
  Destination      S2L-Type  Sub-grp ID  Sub-grp Orig. ID  Operstatus
  +++++++++++      ++++++++  ++++++++++  ++++++++++++++++  ++++++++++
  2.2.2.2          Regular   1           1.1.1.1           Up
  2.2.2.2          Update    4           1.1.1.1           Up
  3.3.3.3          Regular   2           1.1.1.1           Up
  3.3.3.3          Update    5           1.1.1.1           Down
  4.4.4.4          Regular   3           1.1.1.1           Up
 --------------------------------------------------------------------
 LSP-ID   : 65530    LSP-Type: Primary              State   : Up
 LSP-Role : Ingress  Sub-Role:                     #SubLSP: 65535
 --------------------------------------------------------------------
  Destination      S2L-Type  Sub-grp ID  Sub-grp Orig. ID  Operstatus
  +++++++++++      ++++++++  ++++++++++  ++++++++++++++++  ++++++++++
  2.2.2.2          Regular   1           1.1.1.1           Up
  2.2.2.2          Update    4           1.1.1.1           Up
  3.3.3.3          Regular   2           1.1.1.1           Up
  3.3.3.3          Update    5           1.1.1.1           Down
  4.4.4.4          Regular   3           1.1.1.1           Up
 --------------------------------------------------------------------
 LSP-ID   : 65530    LSP-Type: MBB (of LSP 65534)  State   : Up
```

```
 LSP-Role : Ingress  Sub-Role:                    #SubLSP: 65535
 ---------------------------------------------------------------------
  Destination      S2L-Type  Sub-grp ID  Sub-grp Orig. ID  Operstatus
  +++++++++++      ++++++++  ++++++++++  ++++++++++++++++  ++++++++++
  2.2.2.2          Regular   1           1.1.1.1           Up
  2.2.2.2          Update    4           1.1.1.1           Up
  3.3.3.3          Regular   2           1.1.1.1           Up
  3.3.3.3          Update    5           1.1.1.1           Down
  4.4.4.4          Regular   3           1.1.1.1           Up
===========================================================================
```

show rsvp p2mp-session

These commands display detailed output at the Trunk, LSP and Sub-LSP level. The information displayed is for a named session.

```
#show rsvp p2mp-trunk NAME primary-lsp
Trunk-Name     : ABCD:
Trunk-ID       : 100
P2MP-ID        : 10
Ext-Tunnel-ID  : 1.1.1.1
Role           : Ingress
#LSP(s)        : 2
  -----------------------------------
  LSP_ID: 2000   LSP-Role: Primary
  ----------------------------------
   Oper Status          : Up
   Setup priority       : 7
   Hold priority        : 0
   Tspec rate           : 10k
   Fspec rate           : 10k
   Style                : Shared Explicit Filter
   Traffic type         : Controlled-load
   DSTE Class Type No.  : 0
   DSTE Class Type name: Default
   Admin Groups         : None
   LSP Protection       : None
   Retry count          : 0
   Retry interval       : 30 seconds (#remaining: inf)
  #S2L-SubLSP(s)       : 3
   ---------------------------------------------------------------------------
   Sub-Group ID: 1   Sub Group Originator ID: 1.1.1.1    Destination: 2.2.2.2
   ---------------------------------------------------------------------------
     Adminstatus       : Up
     Operstatus        : Up
     Downstream        : 10.10.0.3, eth0
     Minimum Path MTU : N/A
     CSPF usage        : Disabled
     Label in          : -
     Label out         : 606
     Record route      : <self>  ...incomplete
     Label Recording   : Disabled
     Configured Path   : none
     Explicit Path     :
   10.10.0.3/32 strict
   9.10.0.2/32 strict
     Last Recorded Error Code : None
     Last Recorded Error Value: None
```

```
  Node where Last Recorded Error originated: self
---------------------------------------------------------------------------
Sub-Group ID: 2   Sub Group Originator ID: 1.1.1.1    Destination: 3.3.3.3
---------------------------------------------------------------------------
  Adminstatus      : Up
  Operstatus       : Up
  Downstream       : 20.20.0.3, eth1
  Minimum Path MTU : N/A
  CSPF usage       : Disabled
  Label in         : -
  Label out        : 606
  Record route     : <self>  ...incomplete
  Label Recording  : Disabled
  Configured Path  : none
  Explicit Path    :
10.10.0.3/32 strict
9.10.0.2/32 strict
  Last Recorded Error Code : None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: self
---------------------------------------------------------------------------
Sub-Group ID: 3   Sub Group Originator ID: 1.1.1.1    Destination: 4.4.4.4
---------------------------------------------------------------------------
  Adminstatus      : Up
  Operstatus       : Up
  Downstream       : 20.20.0.3, eth2
  Minimum Path MTU : N/A
  CSPF usage       : Disabled
  Label in         : -
  Label out        : 606
  Record route     : <self>  ...incomplete
  Label Recording  : Disabled
  Configured Path  : none
  Explicit Path    :
10.10.0.3/32 strict
9.10.0.2/32 strict
  Last Recorded Error Code : None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: self
```

show rsvp trunk

This command displays brief information abbot a trunk and is enhanced to display P2MP trunk information.

```
#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
T3                   103    P2MP 1     4.4.4.4
                                       5.5.5.5
Total trunks configured: 3.
```

show rsvp trunk detail

These commands are enhanced to display P2MP trunk detail.

```
#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

Trunk name: T3, tunnel-id: 103
 Type: P2MP,    P2MP-ID: 1
 Ext-tunnel-id: 1.1.1.1/32
 Egress: 4.4.4.4/32
         5.5.5.5/32
#of LSPs in trunk: 1
 Mapped-routes: none
```

show mpls p2mp-tunnel

These commands display P2MP FTN entry at the ingress node.

```
#show mpls p2mp-tunnel T2

==========================================================================
Tunnel Name: T2
Owner: RSVP   Tunnel ID: 102     P2MP ID: 102     Ingress: 1.1.1.1
--------------------------------------------------------------------------
LSP#: 102   (Primary)
 FTN Index : 6684774       XC Index: 1            Opcode   : PUSH
 Row Status: Active        Flags   : ACTIVE       XC Count: 1
   --------------   --------------   ---------------    ----------
   Out-seg. Index   Out. Interface   Nexthop Address    Out. Label
   --------------   --------------   ---------------    ----------
   1                eth1             10.1.1.1           53120
--------------------------------------------------------------------------
--------------------------------------------------------------------------
LSP#: 103   (Secondary)
 FTN Index : 6684775       XC Index: 2            Opcode   : PUSH
 Row Status: Active        Flags   : ACTIVE       XC Count: 1
   --------------   --------------   ---------------    ----------
   Out-seg. Index   Out. Interface   Nexthop Address    Out. Label
   --------------   --------------   ---------------    ----------
   2                eth1             10.1.1.1           53121
--------------------------------------------------------------------------
==========================================================================
```

show mpls ilm-table

This command displays multiple ILM entries for transit or branch nodes.

```
#show mpls ilm-table
Codes: > - selected ILM, p - stale ILM, K - CLI ILM, T - MPLS-TP

Code In-Label Out-Label In-Intf Out-Intf Nexthop   FEC ILM-ID   LSP-Type
  >  53121     1001     eth1   eth2      20.1.1.2  NA  2        ELSP_CONFIG
```

```
  >  53120     1000     eth1   eth2      20.1.1.2  NA  1        ELSP_CONFIG
  >   53122    1002     eth1   eth2      20.1.1.2  NA  3        ELSP_CONFIG
=============================================================================
```

show mpls cross-connect table

This command displays multiple entries with the same cross-connects.

```
#show mpls cross-connect-table
     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
==============================================================================
```

show mpls in-segment table

This command displays multiple cross-connected entries for each in-segment for P2MP LSPs.

```
SebOS#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
=============================================================================
```

show mpls out-segment-table

This command displays multiple out-segment table entries mapped to the same `cross-connect ix`.

```
#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:0
===============================================================================
```

show cspf lsp

This command displays list of LSPs serviced by CSFP, with rows for P2MP LSP. One set of data is displayed for each Sub-LSP.

```
R1#show cspf lsp
   P2MP Id          : 102
   Lsp Id           : 0x660066
   Ingress          : 1.1.1.1
   Egress           : 3.3.10.1
   Ext Tunnel ID    : 10.12.17.50
   LSP Type         : 0
   Client ID        : 1
   State            : 3
   Setup Priority   : 7
   Hold Priority    : 0
   Hop Limit        : 65
   Include Mask     : 0x0
   Exclude Mask     : 0x0
   LSP Metric       : 2
   Computed ERO     :
       10.1.1.1
       20.1.1.2
       11.1.10.2

   P2MP Id          : 102
   Lsp Id           : 0x660067
   Ingress          : 1.1.1.1
   Egress           : 3.3.9.1
   Ext Tunnel ID    : 10.12.17.50
   LSP Type         : 0
   Client ID        : 1
   State            : 3
   Setup Priority   : 7
   Hold Priority    : 0
   Hop Limit        : 65
   Include Mask     : 0x0
   Exclude Mask     : 0x0
   LSP Metric       : 2
   Computed ERO     :
       10.1.1.1
       20.1.1.2
       11.1.9.2
```

CHAPTER 6 IP-IP Tunneling Over MPLS

This chapter contains configuration for IP-IP tunnels over MPLS.

For details about the commands, see the *Network Services Module Command Reference*.

IP-IP Tunneling Overview

Tunneling is most often used to transmit private data over a public network such as the Internet. Tunnels allow incompatible data to be carried over an existing network. For example, multicast packets can be transmitted over unicast networks or IPv6 data over IPv4 networks. Secure tunneling protocols (such as IPSec) can be used for transferring sensitive data over public networks.

IP-IP Tunnels that send encrypted IP-over-IP connect two local LANS, allowing them to share data in a secure environment by keeping them behind firewalls. Using MPLS within an IP-IP tunnel enhances forwarding speed by using simple label lookup instead of complex route lookups based on destination IP address.

Topology

In this example, an IP-IP tunnel is created between Router1 and Router6. Within this IP-IP tunnel, an MPLS tunnel is created between Router2 and Router5. Router2 is the ingress router and Router5 an egress router for the MPLS domain. When a packet enters the MPLS domain, Router2 adds an MPLS header to the IP-IP packet and when the packet leaves the MPLS domain at Router5, Router5 removes the MPLS header from the IP-IP packet.

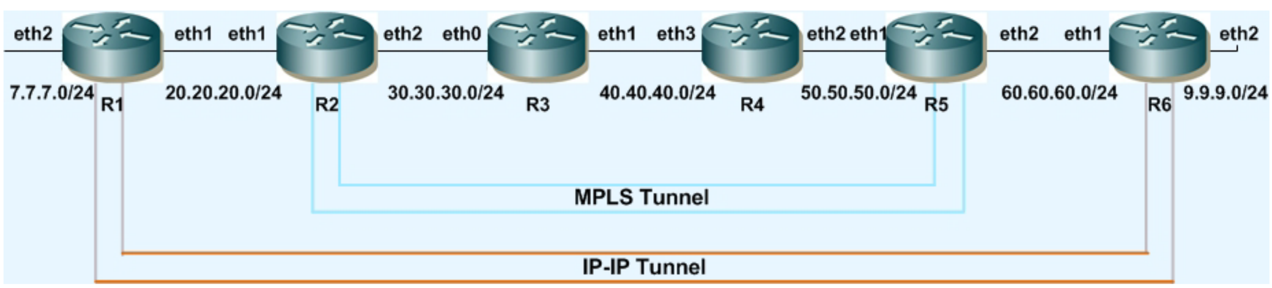


Figure 6-1: IP-IP and MPLS Tunnels

R1

`#configure terminal`	Enter configure mode.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#ip address 20.20.20.17/24`	Set the IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Specify the interface `(eth1)` to be configured.
`(config-if)#ip address 7.7.7.17/24`	Set the IP address for the interface.
`(config-if)#exit`	Exit interface mode.

(config)#interface tunnel110	Create a new tunnel interface.
(config-if)#ip address 8.8.8.17/24	Set the IP address for the interface.
(config-if)#no multicast	Disable multicasting on the interface.
(config-if)#tunnel source 20.20.20.17	Specify the tunnel source address.
(config-if)#tunnel destination 60.60.60.29	Specify the tunnel destination address.
(config-if)#tunnel mode ipip	Configure the IPv4 tunnel mode
(config-if)#exit	Exit interface mode.
(config)#ip route 9.9.9.0/24 tunnel10	Add a static route for the 9.9.9.0/24 route, tunnel as outgoing interface.
(config)#ip route 60.60.60.0/24 20.20.20.84	Establish the distance for static routes of a subnet mask.

R2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the 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)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface eth2	Specify the interface (eth2) to be configured.
(config-if)#ip address 30.30.30.84/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-ldp ipv4	Enable LDP on interface eth2.
(config-if)#exit	Exit interface mode.
(config)#router ospf	Enter the Router mode.
(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)#network 55.55.55.55/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.

R3

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the 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)#exit`	Exit the `Router` mode and return to the `Configure` mode.
`(config)#interface eth0`	Specify the interface `(eth0)` to be configured.
`(config-if)#ip address 30.30.30.82/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface `eth2`.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `eth2`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#ip address 40.40.40.82/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface `eth2`.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `eth2`.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf`	Enter the `Router` mode.
`(config-router)#network 16.16.16.16/32 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 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)#exit`	Exit the `Router` mode and return to the `Configure` mode.
`(config)#router ldp`	Enter `Router` mode.

R4

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter the 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)#exit`	Exit the `Router` mode and return to the `Configure` mode.
`(config)#interface eth2`	Specify the interface `(eth2)` to be configured.
`(config-if)#ip address 50.50.50.48/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface `eth2`.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `eth2`.

`(config-if)#exit`	Exit interface mode.
`(config)#interface eth3`	Specify the interface `(eth3)` to be configured.
`(config-if)#ip address 40.40.40.48/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface `eth3`.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `eth3`.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf`	Enter the `Router` mode.
`(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)#exit`	Exit the `Router` mode and return to the `Configure` mode.
`(config)#router ldp`	Enter `Router` mode.

R5

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter the 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)#exit`	Exit the `Router` mode and return to the `Configure` mode.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#ip address 50.50.50.49/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface `eth1`.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `eth1`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Specify the interface `(eth2)` to be configured.
`(config-if)#ip address 60.60.60.49/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface `eth2`.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `eth2`.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf`	Enter the `Router` mode.
`(config-router)#network 49.49.49.49/32 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.

R6

`#configure terminal`	Enter configure mode.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#ip address 60.60.60.29/24`	Set the IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Specify the interface `(eth2)` to be configured.
`(config-if)#ip address 9.9.9.29/24`	Set the IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface tunnel10`	Create a new tunnel interface.
`(config-if)#ip address 8.8.8.29/24`	Set the IP address for the interface.
`(config-if)#no multicast`	Disable multicasting on the interface.
`(config-if)#tunnel source 60.60.60.29`	Specify the tunnel source address.
`(config-if)#tunnel destination 20.20.20.17`	Specify the tunnel destination address.
`(config-if)#tunnel mode ipip`	Configure the IPv4 tunnel mode
`(config-if)#exit`	Exit interface mode.
`(config)#ip route 7.7.7.0/24 tunnel10`	Add a static route, tunnel as outgoing interface.
`(config)#ip route 20.20.20.0/24 60.60.60.49`	Establish the distance for static routes of a subnet mask.

CHAPTER 7 MPLS OAM Configuration

This chapter contains configuration for MPLS Operations, Administration and Management (OAM).

Overview

MPLS OAM is used to detect forwarding plane failures in an MPLS network. Similar to ICMP echo requests and replies in an IP network, an MPLS network can use MPLS echo requests and replies for checking data plane and control plane operations in the Label Switched Path (LSP). The MPLS traceroute process also provides path details for the LSP.

Topology

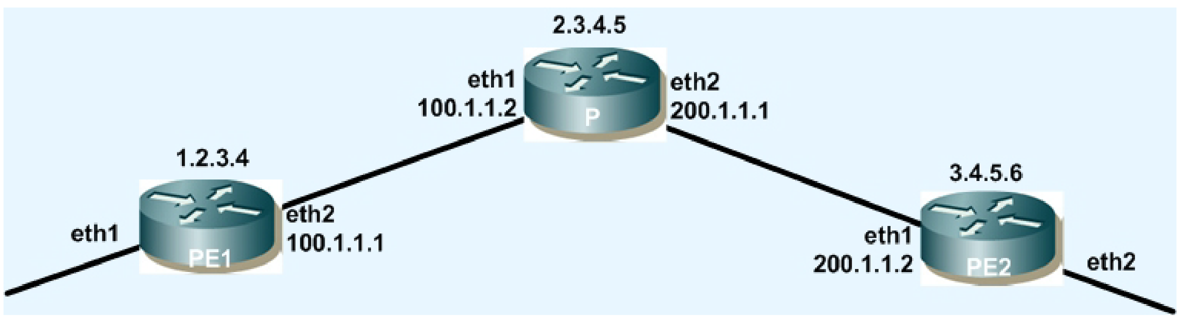


Figure 7-1: Topology for All Configurations

PE1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode for loopback.
`(config-if)#ip address 1.2.3.4/32`	Configure the loopback IP address.
`(config-if)#interface eth1`	Enter interface mode.
`(config-if)#ip address 100.1.1.1/24`	Configure the IP address for interface eth1.
`#exit`	Exit interface mode.
`(config)#router ospf 100`	Configure OSPF.
`(config-router)#network 1.2.3.4/32 area 0`	Add loopback IP address to OSPF network.
`(config)-router#network 100.1.1.0/24 area 0`	Add eth1 IP address to OSPF network.

P

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode for loopback.
`(config-if)#ip address 2.3.4.5/32`	Configure the loopback IP address.
`(config-if)#interface eth1`	Enter interface mode.
`(config-if)#ip address 100.1.1.2/24`	Configure the IP address for interface eth1.
`(config-if)#interface eth2`	Enter interface mode.
`(config-if)#ip address 200.1.1.1/24`	Configure the IP address for interface eth2.
`#exit`	Exit interface mode.
`(config)#router ospf 100`	Configure OSPF.
`(config-router)#network 2.3.4.5/32 area 0`	Add loopback IP address to OSPF network.
`(config)-router#network 100.1.1.0/24 area 0`	Add eth1 IP address to OSPF network.
`(config)-router#network 200.1.1.0/24 area 0`	Add eth2 IP address to OSPF network.

PE2

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode for loopback.
`(config-if)#ip address 3.4.5.6/32`	Configure the loopback IP address.
`(config-if)#interface eth1`	Enter interface mode.
`(config-if)#ip address 200.1.1.2/24`	Configure the IP address for interface eth2.
`#exit`	Exit interface mode.
`(config)#router ospf 100`	Configure OSPF.
`(config-router)#network 3.4.5.6/32 area 0`	Add loopback IP address to OSPF network.
`(config)-router#network 200.1.1.0/24 area 0`	Add eth1 IP address to OSPF network.

Validation

Router 1

```
#show ip ospf neighbor
OSPF process 100:
Neighbor ID   Pri   State       Dead Time   Address     Interface  InstanceID
2.3.4.5       1   Full/DR       00:00:37    100.1.1.2      eth2        0
```

Router 2

```
#show ip ospf neighbor
OSPF process 100:
Neighbor ID   Pri   State       Dead Time   Address      Interface  InstanceID
1.2.3.4       1   Full/Backup    00:00:37    100.1.1.1      eth1        0
3.4.5.6       1   Full/DR        00:00:34    200.1.1.2      eth2        0
```

Router 3

```
#show ip ospf neighbor
OSPF process 100:
Neighbor ID   Pri   State       Dead Time   Address      Interface  InstanceID
2.3.4.5       1   Full/DR       00:00:37    200.1.1.2      eth1       0
```

VCCV and BFD for Pseudowires

The Virtual Circuit Connectivity Verification (VCCV) mechanism is used to facilitate Operations Administration and Maintenance (OAM) in pseudowires (PW). VCCV defines a set of messages that are sent via a PW data stream to enable management functionalities, such as connectivity and verification. Each VCCV packet contains information about its sequence number and the current value of the transmission counter. When a PW receiver receives a VCCV packet, it records the transmission counter contained in the packet. Each PW receiver also has a local received counter, which counts received PW packets. The PW receiver compares the value of the transmission counter with that of the received counter. Packet losses are detected when the count of transmitted packets is greater than the count of received packets.

Bidirectional Forwarding Detection (BFD) is used as one of the connectivity verification mechanisms in VCCV when continuous monitoring is required for a session. BFD VCCV provides a detection mechanism for pseudowires as well as the OAM functions to use over a PW to check its true operational state.

CC Types

- Type 1: PWE3 Control Word with 0001b as first nibble
- Type 2: MPLS Router Alert Label
- Type 3: MPLS PW Label with TTL == 1

VCCV CV Types

- LSP Ping

BFD CV Types

- 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 Signaling
- 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 Signaling

VC with Control-word, VCCV and BFD Enabled

PE1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router LDP mode.
(config-router)#pw-status-tlv	Configure PW status TLV for PW status signaling.
(config-router)#targeted-peer ipv4 3.4.5.6	Configure targeted LDP session to PE2 loopback address.
(config-router)#exit	Exit Router LDP mode and return to Configure mode.
(config)#interface eth2	Enter interface mode.
(config-if)#label-switching	Configure label-switching on provider interface PE1.
(config-if)#enable-ldp ipv4	Enable LDP at provider interface PE1.
(config-if)#exit	Exit interface mode.
(config)#mpls l2-circuit test 100 3.4.5.6 control-word vccv cc-type 1 bfd bfd-cv-type 1	Configure PW named “test” with PW-ID 100 and enable Control-word, VCCV (any CC-Type) and BFD (CV-Type). Note: When Control-word is enabled, only VCCV CV-Type 1 and BFD CV-Type 3 can be used.
(config)#bridge 1 protocol ieee vlan-bridge	Specify VLAN for bridge 1.
(config)#interface eth1	Enter interface mode.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#switchport mode access	Set the switching characteristics of this interface to Access mode.
(config-if)#mpls-l2-circuit test	Bind the PW to access interface.
(config-if)#exit	Exit interface mode.
(config)#exit	Exit Configure mode.

P

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router LDP mode.
(config-router)#pw-status-tlv	Configure PW status TLV for PW status signaling.
(config-router)#exit	Exit Router LDP mode.
(config)#interface eth1	Enter interface mode.
(config-if)#label-switching	Configure label-switching for eth1.
(config-if)#enable-ldp ipv4	Enable LDP for eth1.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#label-switching	Configure label-switching for eth2.
(config-if)#enable-ldp ipv4	Enable LDP for eth2.
(config-if)#exit	Exit interface mode.
(config)#exit	Exit Configure mode.

PE2

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter the `Router LDP` mode.
`(config-router)#pw-status-tlv`	Configure PW status TLV for PW status signaling.
`(config-router)#targeted-peer ipv4 1.2.3.4`	Configure targeted LDP session to PE1 loopback address.
`(config-router)#exit`	Exit `Router LDP` mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#label-switching`	Configure label-switching on provider interface of PE2.
`(config-if)#enable-ldp ipv4`	Enable LDP on the provider interface of PE2.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls l2-circuit test 100 1.2.3.4 control-word vccv cc-type 1 bfd bfd-cv-type 3`	Configure PW named "test" with PW-ID 100 and enable Control-word, VCCV (any CC-type) and BFD (CV-type). Note: When Control-word is enabled, only VCCV CV-Type 1 and BFD CV-Type 3 can be used.
`(config)#bridge 1 protocol ieee vlan-bridge`	Specify VLAN for bridge 1.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#switchport mode access`	Set the switching characteristics of this interface to Access mode.
`(config-if)#mpls-l2-circuit test`	Bind the PW to access interface.
`(config-if)#exit`	Exit interface mode.
`(config)#exit`	Exit `Configure` mode.

Manual VC with VCCV and BFD Enabled

PE1

`(config)#mpls vpls v1 100`	Configure VPLS v1 with id 100 on PE2.
`(config)#router ldp`	Enter the `Router LDP` mode.
`(config-router)#pw-status-tlv`	Configure PW status TLV for PW status signaling.
`(config-router)#targeted-peer ipv4 3.4.5.6`	Configure targeted LDP session to PE2 loopback address.
`(config-router)#exit`	Exit `Router LDP` mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#label-switching`	Configure label-switching on provider interface of PE1.
`(config-if)#enable-ldp ipv4`	Enable LDP on the provider interface of PE1.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls l2-circuit test 100 3.4.5.6 manual vccv cc-type <2> bfd bfd-cv-type <1>`	Configure manual PW named "test" with PW-ID 100 and enable VCCV (any CC-Type) and BFD (CV-Type).
`(config)#mpls l2-circuit-fib-entry 100 111 222 3.4.5.6 eth2 eth1`	Configure mpls-l2 circuit FIB entry for manual VC.

(config)#bridge 1 protocol ieee vlan-bridge	Specify VLAN for bridge 1.
(config)#interface eth1	Enter interface mode.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#switchport mode access	Set the switching characteristics of this interface to Access mode.
(config-if)#mpls-l2-circuit test	Bind the PW to access interface.
(config-if)#exit	Exit interface mode.
(config)#exit	Exit `Configure` mode.

P

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the `Router LDP` mode.
(config-router)#pw-status-tlv	Configure PW status TLV for PW status signaling.
(config-router)#exit	Exit `Router LDP` mode.
(config)#interface eth1	Enter interface mode.
(config-if)#label-switching	Configure label-switching.
(config-if)#enable-ldp ipv4	Enable LDP.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#label-switching	Configure label-switching.
(config-if)#enable-ldp ipv4	Enable LDP.
(config-if)#exit	Exit interface mode.
(config)#exit	Exit `Configure` mode.

PE2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the `Router LDP` mode.
(config-router)#pw-status-tlv	Configure PW status TLV for PW status signalling.
(config-router)#targeted-peer ipv4 1.2.3.4	Configure targeted LDP session to PE1 loopback address.
(config-router)#exit	Exit `Router LDP` mode.
(config)#interface eth1	Enter interface mode.
(config-if)#label-switching	Configure label-switching on provider interface of PE2.
(config-if)#enable-ldp ipv4	Enable LDP on the provider interface of PE2.
(config-if)#exit	Exit interface mode.
(config)#mpls l2-circuit test 100 1.2.3.4 manual vccv cc-type 2 bfd bfd-cv-type 1	Configure manual PW named “test” with PW-ID 100 and enable VCCV (CC-Type) and BFD (CV-Type).
(config)#mpls l2-circuit-fib-entry 100 222 111 1.2.3.4 eth2 eth1	Configure mpls-l2 circuit FIB entry for the manual VC.
(config)#bridge 1 protocol ieee vlan-bridge	Specify the VLAN for bridge 1.

(config)#interface eth2	Enter interface mode.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#switchport mode access	Set the switching characteristics of this interface to Access mode.
(config-if)#mpls-l2-circuit test	Bind the PW to access interface.
(config-if)#exit	Exit interface mode.
(config)#exit	Exit `Configure` mode.

Remove VCCV Configuration

PE1

#configure terminal	Enter configure mode.
(config)#no mpls l2-circuit test 100 3.4.5.6 control-word manual	Remove VC named “test”.
(config)#exit	Exit `Configure` mode.

PE2

#configure terminal	Enter configure mode.
(config)#no mpls l2-circuit test 100 1.2.3.4 control-word manual	Remove VC named “test”.
(config)#exit	Exit `Configure` mode.

Validation

Enter the commands listed in the section below.

Verify BFD Session On PE1

```
#show bfd session detail
--------------------------------------------
Session Interface Index: 4     Session Index: 1
Lower Layer: MPLS VCCV    Version : 1  Session Type: Single Hop
Session State : Up
Local Discriminator : 1 Remote Discriminator: 1
VC ID: 100      Incoming VC Label: 53120
Local Address : 1.2.3.4/32      Remote Address: 127.0.0.12/32
Local Port : 49152      Remote Port: 3784
Options :
Diagnostics: None
Timers in Milliseconds
Min Tx: 20  Min Rx: 20  Multiplier: 5
Min echo Rx: 10   Neg Tx: 20
```

```
Neg echo intrvl: 10     Neg detect mult: 5
Storage type: 0
Last sess down time: 00:00:00
Sess discontinue time: 00:00:00
Counters values:
Pkt In 000000000001ef3a Pkt Out 0000000000000000
Echo Out 0000000000000000
IPv6 Pkt In 0000000000000000 IPv6 Pkt Out 0000000000000000
IPv6 Echo Out 0000000000000000
UP Count: 1  UPTIME: 00:40:26
NSM-> Client ID: 1 Flags: 4
Number of Sessions:    1
```

Verify VCCV and BFD CV Types in Use

```
#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: test, id: 100 PW-INDEX: 1
 Endpoint: 3.4.5.6
 Control Word: 1
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: eth1
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit runtime mode is active
Local VCCV Capability:
 CC-Types:  Type 1(in use) Type 2 Type 3
 CV-Types:
 LSP ping(in use) BFD IP/UDP-encapsulated, for PW Fault Detection only
 BFD IP/UDP-encapsulated, for PW Fault Detection and AC/PW Fault Status Signaling
 BFD PW-ACH-encapsulated, for PW Fault Detection only
 BFD PW-ACH-encapsulated, for PW Fault Detection and AC/PW Fault Status Signaling (in 
use)
```

Verify VCCV Ping on PE1

```
#ping mpls l2-circuit vccv 100 force-explicit-null detail
Sending 5 MPLS Echos to VC 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

 Type 'Ctrl+C' to abort

! seq_num = 1 3.4.5.6 0.54 ms
! seq_num = 2 3.4.5.6 2.36 ms
! seq_num = 3 3.4.5.6 0.47 ms
! seq_num = 4 3.4.5.6 2.22 ms
```

```
! seq_num = 5 3.4.5.6 0.49 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.47/1.42/2.36
```

CHAPTER 8 MPLS Layer-3 VPN Configurations

This chapter contains configurations for MPLS Layer-3 Virtual Private Networks (VPNs).

MPLS Layer-3 VPN 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.

Requirements

To fully implement the ZebOS-XP MPLS Layer-3 VPN solution, the following modules are required:

- Network Services Module
- BGP protocol with VPN extensions
- LDP Module
- MPLS Forwarder Module
- OSPFv2
- RIP

MPLS VPN Terminology

The following illustrates a Virtual Private Network in a CConnect Service Provider Network. This illustration corresponds to the terms defined in this subsection.

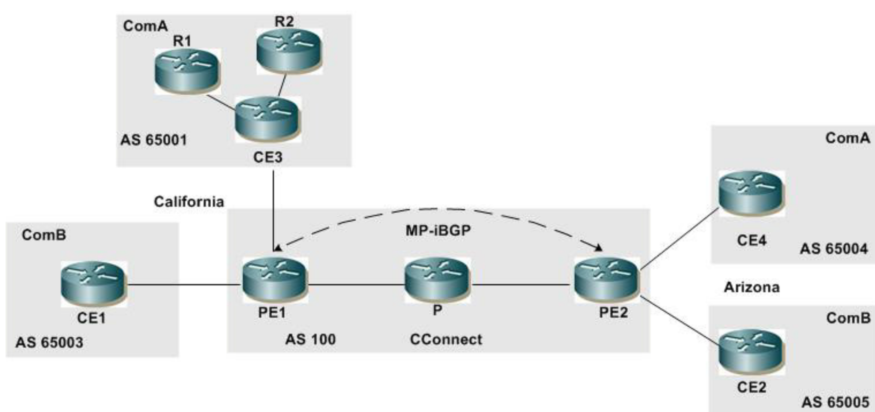


Figure 8-1: CConnect Provider with ComA and ComB Customers

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.

The VPN Routing Process

The ZebOS-XP 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.

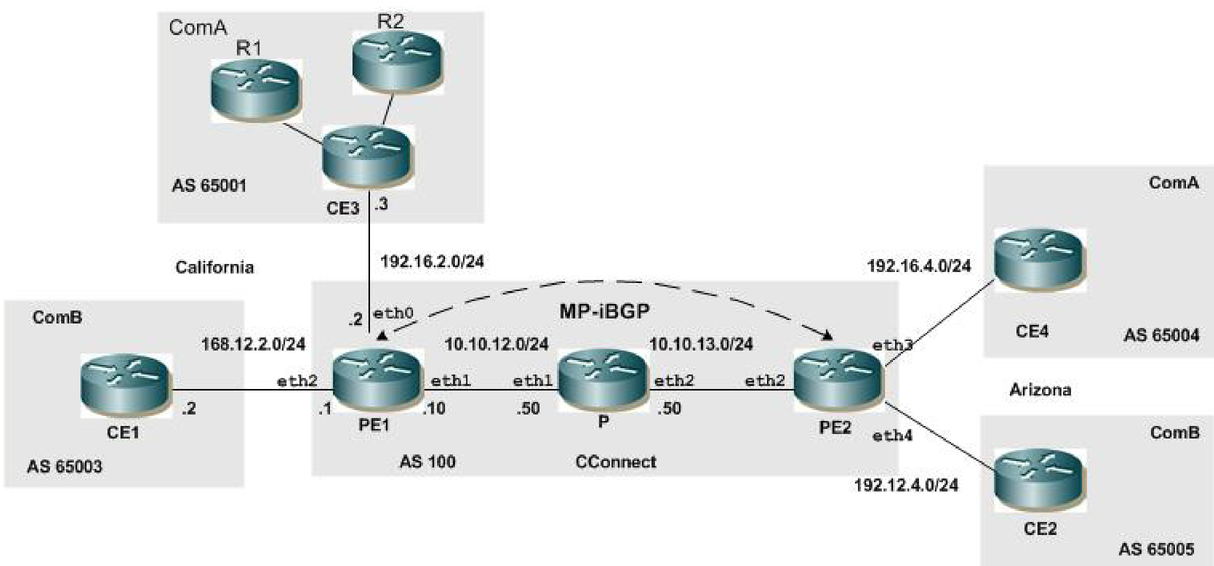


Figure 8-2: Connect Sample Topology

To establish this connection involves three steps:

1. 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 4).

PE1

```
PE1(config)#interface eth1
PE1(config-if)#label-switching
```



```
!
```

P

```
P(config)#interface eth1
P(config-if)#label-switching
!
P(config)#interface eth2
P(config-if)#label-switching
!
```

PE2

```
PE2(config)#interface eth2
PE2(config-if)#label-switching
!
```

2. Enable IGP

What follows is a sample configuration to establish connections between the two Provider Edge routers PE1 and PE2.

Note: For details about OSPF commands, refer to the *Open Shortest Path First Command Reference*.

PE1

```
PE1(config)#router ospf 100
PE1(config-router)#network 10.10.12.0/24 area 0
!
```

P

```
P(config)#router ospf 100
P(config-router)#network 10.10.12.0/24 area 0
P(config-router)#network 10.10.13.0/24 area 0
!
```

PE2

```
PE2(config)#router ospf 100
PE2(config-router)#network 10.10.13.0/24 area 0
!
```

3. Enable Label Switching Protocol

Label switching protocols are used to set up a Label-Switched Path (LSP) between PE routers. ZebOS-XP supports LDP and RSVP-TE protocols for label switching. Enable either LDP or RSVP-TE.

LDP

What follows is a sample configuration to enable LDP on the whole path between PE1 and PE2 (see topology above).

Note: For details about the commands, see the *Label Distribution Protocol Command Reference*.

PE1

```
PE1(config)#interface eth1
PE1(config-if)#enable-ldp
!
PE1(config)#router ldp
PE1(config-router)#advertisement-mode downstream-on-demand
PE1(config-router)#multicast-hellos
!
```


P

```
P(config)#interface eth1
P(config-if)#enable-ldp
P(config)#interface eth2
P(config-if)#enable-ldp
!
!
P(config)#router ldp
P(config-router)#advertisement-mode downstream-on-demand
P(config-router)#multicast-hellos
!
```

PE2

```
PE2(config)#interface eth2
PE2(config-if)#enable-ldp
!
!
PE2(config)#router ldp
PE2(config-router)#advertisement-mode downstream-on-demand
PE2(config-router)#multicast-hellos
!
```

RSVP-TE

What follows is a sample configuration to enable RSVP-TE along the entire path between PE1 and PE2 (refer to the sample topology diagram).

Note: For details about the commands, see the *RSVP-TE Command Reference*.

PE1

```
PE1(config)#router rsvp
!
PE1(config)#rsvp-path p1
PE1(config-path)#10.10.12.50 loose
!
PE1(config)#rsvp-trunk t1
PE1(config-rsvp)#primary path p1
PE1(config-rsvp)#from 2.2.2.2
PE1(config-rsvp)#to 3.3.3.3
!
PE1(config)#interface eth1
PE1(config-if)#enable-rsvp
```

P

```
P(config)#router rsvp
!
P(config)#interface eth1
P(config-if)#enable-rsvp
!
P(config)#interface eth2
P(config-if)#enable-rsvp
!
```

PE2

```
PE2(config)#router rsvp
!
```



```
PE2(config)#rsvp-trunk t1
PE2(config-rsvp)#from 3.3.3.3
PE2(config-rsvp)#to 2.2.2.2
!
PE2(config)#interface eth2
PE2(config-if)#enable-rsvp
```

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.

Note: For details about BGP commands, refer to the *Border Gateway Protocol Command Reference*.

PE1

```
PE1(config)#interface lo
PE1(config-if)#ip address 2.2.2.2/32
```

PE2

```
PE2(config)#interface lo
PE2(config-if)#ip address 3.3.3.3/32
!
```

PE1

```
PE1#configure terminal
PE1(config)#router bgp 100
PE1(config-router)#neighbor 3.3.3.3 remote-as 100
PE1(config-router)#neighbor 3.3.3.3 update-source 2.2.2.2
!
PE1(config-router)#address-family vpnv4 unicast
PE1(config-router-af)#neighbor 3.3.3.3 activate
!
```

PE2

```
PE2(config)#router bgp 100
PE2(config-router)#neighbor 2.2.2.2 remote-as 100
PE2(config-router)#neighbor 2.2.2.2 update-source 3.3.3.3
!
!
PE2(config-router)#address-family vpnv4 unicast
PE2(config-router-af)#neighbor 2.2.2.2 activate
!
```

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. Use the following command to create the VRF (see the *Border Gateway Protocol Command Reference* for details):

```
ip vrf VRF-NAME
```

`VRF-NAME` a name used to identify the VRF.

This command creates a VRF RIB (Routing Information Base), assigns a VRF-ID, and switches the command mode to `vrf` mode. The following example demonstrates the use of the command to create a VRF named `ComB`.

```
(config)#ip vrf ComB
(config-vrf)#
```

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. To associate the interfaces (connected to the CE routers) to the VRFs, use the following command in the Interface mode (see the *Border Gateway Protocol Command Reference* for details):

```
ip vrf forwarding VRF-NAME
```

In the following example, interface `eth1` is associated with the VRF named `ComB`.

```
(config)#interface eth1
(config-if)#ip vrf forwarding ComB
```

Configure VRF—RD and Route Targets

After the VRF is created, configure Router Distinguishers and the Route Targets.

1. 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. Using the following command in the `Configure vrf` mode (see the *Border Gateway Protocol Command Reference*):

```
rd RD-VALUE
```

`RD-VALUE` = `ASN|IPID`

`ASN` = `AS Number:NN` This is a 16-bit AS number and an arbitrary number (for example 100:1)

`IPID` = `A.B.C.D|NN` This is a 32-bit IP address and an arbitrary number (for example 192.34.23.1:1)

To display the routing table for this VRF, use the `show ip route vrf` command.

The following example shows the addition of RD:

```
(config)#ip vrf ComB
(config-vrf)#rd 1:1
```

2. 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. Use the following command to configure the route targets (see the *Border Gateway Protocol Command Reference*):

```
route-target [export|import|both] RT-VALUE
```

`export` Add route-target to the exporting routing information from the VRF

`import` Import routing information which have this route-target `both` Specify both import and export

`RT-VALUE` = `ASN|IPID`

`ASN` = `ASN:NN` 16-bit This is an AS number and an arbitrary number (for example 100:1)

`IPID` = `A.B.C.D|NN` This is a 32-bit IP address and an arbitrary number (for example 192.34.23.1:1)

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 for `ComB`.

```
bgpd(config)#ip vrf ComB
bgpd(config-vrf)#route-target both 100:1
```

Configure CE Neighbor for the VPN (Using BGP/ OSPF/ RIP)

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 (RIP, OSPF, BGP or static routes etc). Use any one of the following configurations (BGP, OSPF or RIP) 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. To enter the address-family mode, use the following command (see the *Border Gateway Protocol Command Reference* for details):

```
address-family ipv4 vrf VRF-NAME
```

`VRF-NAME` a name used to identify a VRF

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

```
PE1(config)#router bgp 100
PE1(config-router)#address-family ipv4 vrf ComA
PE1(config-router-af)#neighbor 192.16.3.3 remote-as 65001
!
PE1(config-router)#address-family ipv4 vrf ComB
PE1(config-router-af)#neighbor 168.12.0.2 remote-as 65003
```

Using OSPF

Unlike BGP and RIP, 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

```
PE1(config)#router ospf 101 comA
PE1(config-router)#network 192.16.3.0/24 area 0
PE1(config-router)#redistribute bgp

PE1(config)#router ospf 102 comB
PE1(config-router)#network 192.12.0.0/24 area 0
PE1(config-router)#redistribute bgp
```

PE1

```
PE1(config)#router bgp 100
PE1(config-router)#address-family ipv4 vrf ComA
PE1(config-router-af)#redistribute ospf
!
PE1(config-router)#address-family ipv4 vrf ComB
PE1(config-router-af)#redistribute ospf
```

Using RIP

To run RIP between the PE and CE routers, the CE router is placed into the connected VRF for the receiving interfaces, and then advertised across the MPLS/VPN backbone between PE routers. To redistribute VRF RIP routes into BGP, redistribute RIP under the BGP VRF address family submode.

The address-family sub mode within the main RIP process configuration is used for configuring the CE neighbor. The PE router interprets the commands entered in this sub-mode as belonging to the specified VRF.

PE1

```
PE1(config)#router rip
PE1(config-router)#address-family ipv4 vrf ComA
PE1(config-router-af)#network 192.16.3.0/24
PE1(config-router-af)#redistribute bgp

PE1(config-router)#address-family ipv4 vrf ComB
PE1(config-router-af)#network 192.12.0.0/24
PE1(config-router-af)#redistribute bgp
```

PE1

```
PE1(config)#router bgp 100
PE1(config-router)#address-family ipv4 vrf ComA
PE1(config-router-af)#redistribute rip
!
PE1(config-router)#address-family ipv4 vrf ComB
PE1(config-router-af)#redistribute rip
```

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 (see the *Border Gateway Protocol Command Reference* for details) to display all the VRFs and the routes associated with them. The following is sample output for the `show running-config` command for the `PE1`, `CE1 and P` routers displaying the complete configuration (based on the topology in the diagram above).

Note: In this example, BGP was used to configure the PE to CE link.

```
!
hostname CE1
password zebra
log stdout
!
interface lo
!
interface eth0
!
interface eth1
!
interface sit0
!
interface ppp0
!
interface eth2
 ip address 168.12.2.2/24
!
interface eth3
!
router bgp 65003
 bgp router-id 10.10.10.10
 redistribute connected
 neighbor 168.12.2.1 remote-as 100
!
---------------------------------------------------------------------------
!
hostname PE1
password zebra
log stdout
!
ip vrf ComB
 rd 1:1
 route-target both 100:1
!
ip vrf ComA
 rd 1:2
 route-target both 100:2
!
interface lo
 ip address 2.2.2.2/32
!
```



```
interface eth0
 ip address 192.16.3.2/24
 ip vrf forwarding ComA
!
interface eth1
 label-switching
 ip address 10.10.12.10/24
 enable-ldp
!
interface eth2
 ip address 168.12.2.1/24
 ip vrf forwarding ComB
!
interface sit0
!
interface ppp0
!
router bgp 100
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source 2.2.2.2
!
 address-family vpnv4 unicast
 neighbor 3.3.3.3 activate
 exit-address-family
!
 address-family ipv4 vrf ComB
 neighbor 168.12.2.2 remote-as 65003
 no neighbor 168.12.2.2 send-community extended
 exit-address-family
!
 address-family ipv4 vrf ComA
 neighbor 192.16.3.3 remote-as 65001
 no neighbor 192.16.3.3 send-community extended
 exit-address-family
!
router ldp
 advertisement-mode downstream-on-demand
 loop-detection
!
router ospf 100
 redistribute connected
 network 10.10.12.0/24 area 0
!
---------------------------------------------------------------------
!
hostname P
password zebra
log stdout
!
interface lo
```

```
!
interface eth0
!
interface eth1
 label-switching
 ip address 10.10.12.50/24
 enable-ldp
!
interface eth2
 label-switching
 ip address 10.10.13.50/24
 enable-ldp
!
interface eth3
!
interface eth4
!
interface sit0
!
interface ppp0
!
router ldp
 advertisement-mode downstream-on-demand
 loop detection
!
router ospf 100
 redistribute connected
 network 10.10.12.0/24 area 0
 network 10.1.13.0/24 area 0
```

Configure 6PE Solutions

This section explains how to interconnect IPv6 islands over an MPLS-enabled IPv4 cloud. This approach relies on IPv6 Provider Edge (6PE) routers, which are Dual Stack, to connect to IPv6 islands and the MPLS core, in which it is only necessary to run IPv4 MPLS. The 6PE routers exchange IPv6 reachability information transparently over the core using the Multi-Protocol Border Gateway Protocol (MP-BGP) over IPv4. In this illustration, 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.

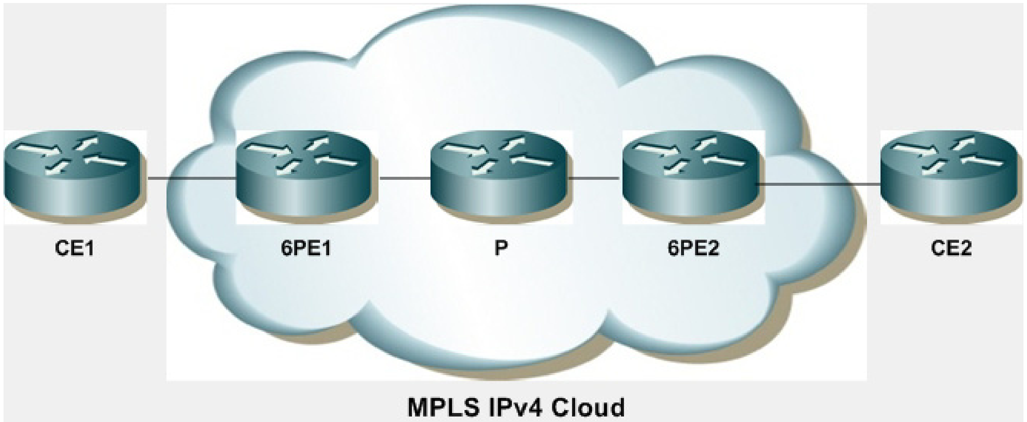


Figure 8-3: 6PE in an IPv4 MPLS Cloud

6PE Routers with Dual Stack and iBGP Peering

In this example, EBGP4+ is configured between CE and PE routers. The 6PE routers have iBGP peering.

CE1 and CE 2

`#configure terminal`	Enter Configure mode.
`(config)#router bgp 200`	Enter BGP Configure mode.
`(config-router)#neighbor fe80:250:8bff:febe:464b remote-as 100`	Configure 6PE1 as an eBGP4+ neighbor.
`(config-router)#neighbor fe80::250:8bff:febe:464b interface eth2`	Configure eth2 as the outgoing interface for the same neighbor.
`(config-router)#address-family ipv6 unicast`	Enter Address-Family IPv6 unicast mode.
`(config-router-af)#neighbor fe80::250:8bff:febe:464b activate`	Activate the neighbor in the IPv6 address family.
`(config-router-af)#exit`	Exit twice.
`(config)#ipv6 route 2ffe::/64 eth1`	Configure a static route to advertise under BGP.
`(config-router-af)#redistribute static`	Redistribute the static route under address family IPv6 unicast.

6PE1 and 6PE2

`#configure terminal`	Enter Configure mode.
`(config)#router bgp 100`	Enter BGP Configure mode.
`(config-router)#neighbor 5.5.5.5 remote-as 100`	Configure 6PE1 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 6PE router.
`(Config-router)#neighbor fe80::207:e9ff:fea5:1d0c remote-as 200`	Configure CE as an eBGP4+ peer.
`(config-router)#neighbor fe80::207:e9ff:fea5:1d0c interface eth1`	Configure the local outgoing interface for the eBGP peering with CE.
`(config-router)#address-family ipv6`	Configure address-family IPv6.

`(config-router-af)#neighbor fe80::207:e9ff:fea5:1d0c activate`	Activate CE in the IPv6 address family.
`(config-router-af)#exit-address-family`	Exit from the IPv6 address family.
`(config-router)#address-family ipv6 labeled-unicast`	Configure the labeled unicast address-family under BGP for sending labels for IPv6 prefixes over the IPv4 cloud.
`(config-router-af)#neighbor 5.5.5.5 activate`	Activate the remote 6PE router under address-family IPv6 labeled-unicast.
`(config-router-af)#exit-address-family`	Exit the specified address family.

Validation

show ipv6 route, show ip bgp neighbors, show bgp neighbors, show bgp ipv6 labeled, show mpls ftn-table, show mpls ilm-table, show mpls forwarding-table

6PE Routers with Dual Stack and eBGP Peering

In this example, EBGP4+ is configured between CE and PE routers. The 6PE routers have eBGP peering.

Configuration for CE Routers

Configure the CE routers the same way as in 6PE Routers with Dual Stack and iBGP Peering.

6PE1 and 6PE2

`#configure terminal`	Enter Configure mode.
`(config)#router bgp 400`	Configure bgp with AS 400, which is different from the remote PE router (AS 100).
`(config-router)#neighbor 5.5.5.5 ebgp-multihop 255`	Enable eBGP multihop for eBGP peering, because of the P router in the middle.
`(config-router)#neighbor 5.5.5.5 update-source lo`	Update the loopback as the source for eBGP peering.
`(config-router)#neighbor fe80::207:e9ff:fea5:1d0c remote-as 200`	Configure CE as an eBGP4+ peer with AS 200.
`(config-router)#neighbor fe80::207:e9ff:fea5:1d0c interface eth1`	Configure the outgoing interface for eBGP4+ peering with CE.
`(config-router)#address-family ipv6`	Configure address-family IPv6.
`(config-router-af)#neighbor fe80::207:e9ff:fea5:1d0c activate`	Activate CE in the IPv6 address family.
`(config-router-af)#exit-address-family`	Exit from the IPv6 address family.
`(config-router)#address-family ipv6 labeled-unicast`	Configure the labeled unicast address-family under BGP for sending labels for IPv6 prefixes over the IPv4 cloud.
`(config-router-af)#neighbor 5.5.5.5 activate`	Activate the remote 6PE router under address-family IPv6 labeled-unicast.
`(config-router-af)#exit-address-family`	Exit the address family mode.

Validation

show ipv6 route, show ip bgp neighbors, show bgp neighbors, show bgp ipv6 labeled, show mpls ftn-table, show mpls ilm-table, show mpls forwarding-table

CE-6PE Routers with IPv4 and IPv6 Peering

In this example IPv4 and IPv6 peering is configured between PE and CE routers. In this case, IPv4 routes must be passed normally, and no labels are generated for IPv4 routes on the PE router from the CE router.

CE1 and CE2

`#configure terminal`	Enter Configure mode.
`(config)#router bgp 200`	Configure BGP in CE with AS 200.
`(config-router)#neighbor 5.1.1.3 remote-as 100`	Configure 6PE1 as an IPv4 eBGP4 neighbor.
`(config-router)#neighbor fe80::250:8bff:febe:464b remote-as 100`	Configure the same 6PE neighbor as an eBGP4+ neighbor.
`(config-router)#neighbor fe80::250:8bff:febe:464b interface eth2`	Configure the outgoing interface for the eBGP4+ peer.
`(config-router)#address-family ipv6`	Enter Address-Family IPv6 mode.
`(config-router-af)#neighbor fe80::250:8bff:febe:464b activate`	Activate the 6PE neighbor in the IPv6 address family.
`(config-router-af)#exit-address-family`	Exit the IPv6 address family.

Validation

show ip bgp neighbors, show bgp ipv6 neighbors, show ipv6 route

Configuration for 6PE Routers

6PEs1 and 6PE2

`#configure terminal`	Enter Configure mode.
`(config)#router bgp 100`	Configure BGP with AS 100.
`(config-router)#neighbor 5.1.1.2 remote-as 200`	Configure the CE router as an IPv4 eBGP peer.
`(config-router)#neighbor 5.5.5.5 remote-as 100`	Configure the remote 6PE as an eBGP peer with AS 100.
`(config-router)#neighbor 5.5.5.5 update-source lo`	Update the source as loopback for iBGP peering with the remote 6PE router.
`(Config-router)#neighbor fe80::207:e9ff:fea5:1d0c remote-as 200`	Configure CE as an eBGP4+ peer.
`(config-router)#neighbor fe80::207:e9ff:fea5:1d0c interface eth1`	Configure the local outgoing interface for eBGP4+ peering with CE.
`(config-router)#address-family ipv6`	Configure address-family IPv6.
`(config-router-af)#neighbor fe80::207:e9ff:fea5:1d0c activate`	Activate CE in the IPv6 address family.
`(config-router-af)#exit-address-family`	Exit from the IPv6 address family.
`(config-router)#address-family ipv6 labeled-unicast`	Configure the labeled unicast address-family under BGP for sending labels for IPv6 prefixes over the IPv4 cloud.

`(config-router-af)#neighbor 5.5.5.5 activate`	Activate the remote 6PE router under address-family IPv6 labeled-unicast.
`(config-router-af)#exit-address-family`	Exit the specified address family.

Validation

show ipv6 route, show ip bgp neighbors, show bgp neighbors, show bgp ipv6 labeled, show mpls ftn-table, show mpls ilm-table, show mpls forwarding-table, show ip route

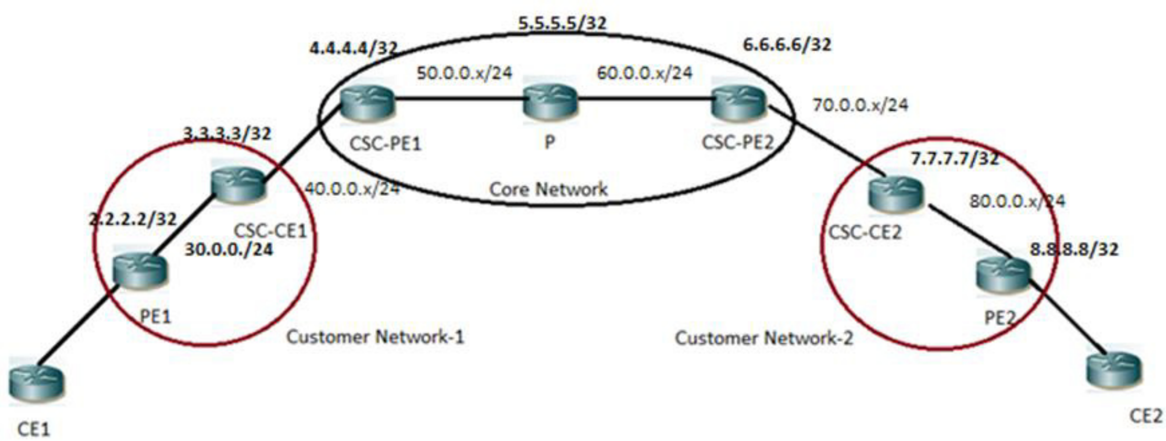
Configure Carrier Supporting Carrier (CSC) solutions

This section details the use-case of deploying carrier supporting carrier over L3VPN topology.

The prerequisite for ensuring CSC is the support for RFC 3107 which deals with carrying label information in BGP-v4. CSC is enabled by configuring the CE-PE -- CSC-CE peers to exchange labels and thereby interconnect networks via a core network running L3VPN.

Topology

In this example, EBGPv4+ is configured between the CSC-CE, CSC-PE peers and a MP-BGP (VPNv4) session is configured between the CSC-PE peers. The PE peers have an IBGP session between them.



In this example, EBGPv4+ is configured between the CSC-CE, CSC-PE peers and a MP-BGP (VPNv4) session is configured between the CSC-PE peers. The PE peers have an IBGP session between them.

The configurations for BGP instances, OSPF instances are same as that detailed in the L3VPN configuration section.

To enable the functionality of CSC the following command needs to be configured on CSC-PE and CSC-CE peers under their respective BGP router instances – “neighbor x.x.x.x send-label explicit-null”. The running configurations are shown below.

The running configurations are shown here:

Configuration of PE routers:

PE1

```
!
no service password-encryption
!
ip vrf management
!
ip vrf VRF-2
 rd 1:200
 route-target both 1:200
!
mpls propagate-ttl
!
ip domain-lookup
no ip icmp-broadcast
spanning-tree mode provider-rstp
data-center-bridging enable
!
router ldp
 explicit-null
 transport-address ipv4 2.2.2.2
!
interface lo
 ip address 127.0.0.1/8
 ip address 2.2.2.2/32 secondary
 ipv6 address ::1/128
 no shutdown
 no snmp trap link-status
!
interface p2p1
 ip vrf forwarding VRF-2
 ip address 23.0.0.2/24
 no shutdown
 no snmp trap link-status
!
interface p7p1
 ip address 30.0.0.1/24
 no shutdown
 label-switching
 no snmp trap link-status
 enable-ldp ipv4
!
interface p9p1
 ip address 10.0.5.15/24
 no shutdown
 no snmp trap link-status
!
router ospf
```



```
 redistribute bgp
 network 2.2.2.2/32 area 0.0.0.200
 network 30.0.0.0/24 area 0.0.0.200
 cspf disable-better-protection
!
router bgp 200
 neighbor 8.8.8.8 remote-as 200
 neighbor 8.8.8.8 update-source 2.2.2.2
 address-family vpnv4 unicast
 neighbor 8.8.8.8 activate
 exit-address-family
 !
 address-family ipv4 vrf VRF-2
 redistribute connected
 redistribute static
 redistribute ospf
 exit-address-family
!
```

PE2

```
!
no service password-encryption
!
ip vrf management
!
ip vrf VRF-2
 rd 1:200
 route-target both 1:200
!
mpls propagate-ttl
!
ip domain-lookup
no ip icmp-broadcast
spanning-tree mode provider-rstp
data-center-bridging enable
!
router ldp
 transport-address ipv4 8.8.8.8
!
interface lo
 ip address 127.0.0.1/8
 ip address 8.8.8.8/32 secondary
 ipv6 address ::1/128
 no shutdown
 no snmp trap link-status
!
interface p2p1
 ip address 80.0.0.2/24
 no shutdown
 label-switching
```

```
 no snmp trap link-status
 enable-ldp ipv4
!
interface p7p1
 ip vrf forwarding VRF-2
 ip address 33.0.0.2/24
 no shutdown
 no snmp trap link-status
!
interface p8p1
 no shutdown
 no snmp trap link-status
!
interface p9p1
 ip address 10.0.5.15/24
 no shutdown
 no snmp trap link-status
!
interface svlan0.1
 no shutdown
 no snmp trap link-status
!
router ospf
 network 8.8.8.8/32 area 0.0.0.200
 network 80.0.0.0/24 area 0.0.0.200
 cspf disable-better-protection
!
router bgp 200
 neighbor 2.2.2.2 remote-as 200
 neighbor 2.2.2.2 update-source 8.8.8.8
 address-family vpnv4 unicast
 neighbor 2.2.2.2 activate
 exit-address-family
  !
 address-family ipv4 vrf VRF-2
 redistribute connected
 redistribute static
 redistribute ospf
 exit-address-family
!
```

Configuring CSC-CE routers

CSC-CE1

```
!
no service password-encryption
!
ip vrf management
!
```

```
mpls propagate-ttl
!
ip domain-lookup
no ip icmp-broadcast
spanning-tree mode provider-rstp
data-center-bridging enable
!
interface lo
 ip address 127.0.0.1/8
 ip address 3.3.3.3/32 secondary
 ipv6 address ::1/128
 no shutdown
 no snmp trap link-status
!
interface p2p1
 ip address 30.0.0.2/24
 no shutdown
 label-switching
 no snmp trap link-status
!
interface p7p1
 ip address 40.0.0.1/24
 no shutdown
 label-switching
 no snmp trap link-status
!
interface p8p1
 no shutdown
 no snmp trap link-status
!
interface p9p1
 ip address 10.0.5.15/24
 no shutdown
 no snmp trap link-status
!
interface svlan0.1
 no shutdown
 no snmp trap link-status
!
router ospf
 redistribute bgp
 network 3.3.3.3/32 area 0.0.0.200
 network 30.0.0.0/24 area 0.0.0.200
 cspf disable-better-protection
!
router bgp 200
 redistribute connected
 redistribute ospf
 neighbor 40.0.0.2 remote-as 100
```



```
 neighbor 40.0.0.2 send-label explicit-null
 neighbor 40.0.0.2 update-source lo
!
```

CSC-CE2

```
!
no service password-encryption
!
ip vrf management
!
mpls propagate-ttl
!
ip domain-lookup
no ip icmp-broadcast
spanning-tree mode provider-rstp
data-center-bridging enable
!
router ldp
 transport-address ipv4 7.7.7.7
!
interface lo
 ip address 127.0.0.1/8
 ip address 7.7.7.7/32 secondary
 ipv6 address ::1/128
 no shutdown
 no snmp trap link-status
!
interface p2p1
 ip address 70.0.0.2/24
 no shutdown
 label-switching
 no snmp trap link-status
!
interface p7p1
 ip address 80.0.0.1/24
 no shutdown
 label-switching
 no snmp trap link-status
 enable-ldp ipv4
!
interface p8p1
 no shutdown
 no snmp trap link-status
!
interface p9p1
 ip address 10.0.5.15/24
 no shutdown
 no snmp trap link-status
!
```

```
interface svlan0.1
 no shutdown
!
router ospf
 redistribute bgp
 network 7.7.7.7/32 area 0.0.0.200
 network 80.0.0.0/24 area 0.0.0.200
 cspf disable-better-protection
!
router bgp 200
 redistribute connected
 redistribute ospf
 neighbor 70.0.0.1 remote-as 100
 neighbor 70.0.0.1 send-label explicit-null
 neighbor 70.0.0.1 update-source lo
!
```

Configuring CSC-PE routers

CSC-PE1

```
!
no service password-encryption
!
ip vrf management
!
ip vrf VRF-1
 rd 1:100
 route-target both 1:100
!
mpls propagate-ttl
mpls log all
!
ip domain-lookup
no ip icmp-broadcast
spanning-tree mode provider-rstp
data-center-bridging enable
!
router ldp
 transport-address ipv4 4.4.4.4
!
interface lo
 ip address 127.0.0.1/8
 ip address 4.4.4.4/32 secondary
 ipv6 address ::1/128
 no shutdown
 no snmp trap link-status
!
interface p2p1
 ip vrf forwarding VRF-1
```



```
 ip address 40.0.0.2/24
 no shutdown
 label-switching
 no snmp trap link-status
!
interface p7p1
 ip address 50.0.0.1/24
 no shutdown
 label-switching
 no snmp trap link-status
 enable-ldp ipv4
!
interface p8p1
 no shutdown
 no snmp trap link-status
!
interface p9p1
 ip address 10.0.5.15/24
 no shutdown
 no snmp trap link-status
!
interface svlan0.1
 no shutdown
 no snmp trap link-status
!
router ospf
 redistribute bgp
 network 4.4.4.4/32 area 0.0.0.100
 network 50.0.0.0/24 area 0.0.0.100
 cspf disable-better-protection
!
router bgp 100
 bgp router-id 4.4.4.4
 neighbor 6.6.6.6 remote-as 100
 neighbor 6.6.6.6 update-source lo
 address-family vpnv4 unicast
 neighbor 6.6.6.6 activate
 exit-address-family
 !
 address-family ipv4 vrf VRF-1
 redistribute connected
 redistribute static
 redistribute ospf
 neighbor 40.0.0.1 remote-as 200
 neighbor 40.0.0.1 send-label explicit-null
 neighbor 40.0.0.1 activate
 no neighbor 40.0.0.1 send-community extended
 neighbor 40.0.0.1 as-override
 exit-address-family
!
```

CSC-PE2

```
!
no service password-encryption
!
debug nsm events
!
ip vrf management
!
ip vrf VRF-1
 rd 1:0
 route-target both 1:100
!
mpls propagate-ttl
!
ip domain-lookup
no ip icmp-broadcast
spanning-tree mode provider-rstp
data-center-bridging enable
!
router ldp
 targeted-peer ipv4 4.4.4.4
  exit-targeted-peer-mode
 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
 no shutdown
!
interface p2p1
 ip address 60.0.0.2/24
 no shutdown
 label-switching
 enable-ldp ipv4
!
interface p7p1
 ip vrf forwarding VRF-1
 ip address 70.0.0.1/24
 no shutdown
 label-switching
!
interface p8p1
 no shutdown
!
interface p9p1
 ip address 10.0.5.15/24
 no shutdown
!
interface svlan0.1
```



```
 no shutdown
!
router ospf
 redistribute bgp
 network 6.6.6.6/32 area 0.0.0.100
 network 60.0.0.0/24 area 0.0.0.100
 cspf disable-better-protection
!
router bgp 100
 bgp router-id 6.6.6.6
 neighbor 4.4.4.4 remote-as 100
 neighbor 4.4.4.4 update-source lo
 address-family vpnv4 unicast
 neighbor 4.4.4.4 activate
 exit-address-family
 !
 address-family ipv4 vrf VRF-1
 redistribute connected
 redistribute static
 redistribute ospf
 neighbor 70.0.0.2 remote-as 200
 neighbor 70.0.0.2 send-label explicit-null
 neighbor 70.0.0.2 activate
 no neighbor 70.0.0.2 send-community extended
 neighbor 70.0.0.2 as-override
 exit-address-family
!
```

The configuration for the intermediate P router which is part of the PSN network running LDP is shown below:

P

```
!
no service password-encryption
!
ip vrf management
!
mpls propagate-ttl
mpls log all
!
ip domain-lookup
no ip icmp-broadcast
spanning-tree mode provider-rstp
data-center-bridging enable
!
router ldp
 transport-address ipv4 5.5.5.5
!
interface lo
 ip address 127.0.0.1/8
 ip address 5.5.5.5/32 secondary
 ipv6 address ::1/128
```

```
 no shutdown
 no snmp trap link-status
!
interface p2p1
 ip address 50.0.0.2/24
 no shutdown
 label-switching
 no snmp trap link-status
 enable-ldp ipv4
!
interface p7p1
 ip address 60.0.0.1/24
 no shutdown
 label-switching
 no snmp trap link-status
 enable-ldp ipv4
!
interface p8p1
 no shutdown
 no snmp trap link-status
!
interface p9p1
 ip address 10.0.5.15/24
 no shutdown
 no snmp trap link-status
!
interface svlan0.1
 no shutdown
 no snmp trap link-status
!
router ospf
 network 5.5.5.5/32 area 0.0.0.100
 network 50.0.0.0/24 area 0.0.0.100
 network 60.0.0.0/24 area 0.0.0.100
 cspf disable-better-protection
!
```

Validation commands

Show mpls vrf-table, show ip bgp vpnv4 vrf <vrf-name> label, show ip bgp neighbors, show mpls ilm-table, show ip route vrf <vrf-name>

Validation for CSC-CE1

```
CSC-CE1# 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
       * - candidate default

IP Route Table for VRF "default"
```



```
Gateway of last resort is 10.0.5.2 to network 0.0.0.0

K*      0.0.0.0/0 [0/0] via 10.0.5.2, p9p1
O       2.2.2.2/32 [110/11] via 30.0.0.1, p2p1, 17:36:25
C       3.3.3.3/32 is directly connected, lo
B       7.7.7.7/32 [20/0] via 40.0.0.2, p7p1, 01:04:40
B       8.8.8.8/32 [20/0] via 40.0.0.2, p7p1, 01:04:40
C       10.0.5.0/24 is directly connected, p9p1
C       30.0.0.0/24 is directly connected, p2p1
C       40.0.0.0/24 is directly connected, p7p1
B       70.0.0.0/24 [20/0] via 40.0.0.2, p7p1, 01:04:40
B       80.0.0.0/24 [20/0] via 40.0.0.2, p7p1, 01:04:40
CSC-CE1#sh mpls forwarding-table
Codes: > - selected FTN, p - stale FTN, B - BGP FTN, K - CLI FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN

Code    FEC                 FTN-ID    Tunnel-id   Pri  Nexthop         Out-Label    Out-
Intf     LSP-Type
B>     7.7.7.7/32         1        0         Yes  40.0.0.2        0          p7p1
LSP_DEFAULT
B>     8.8.8.8/32         3        0         Yes  40.0.0.2        0          p7p1
LSP_DEFAULT
B>     70.0.0.0/24        4        0         Yes  40.0.0.2        0          p7p1
LSP_DEFAULT
B>     80.0.0.0/24        2        0         Yes  40.0.0.2        0          p7p1
LSP_DEFAULT
```

On CSC-PE1:

```
CSC-PE1# show ip route vrf all
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
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.0.5.2 to network 0.0.0.0

K*      0.0.0.0/0 [0/0] via 10.0.5.2, p9p1
C       4.4.4.4/32 is directly connected, lo
O       5.5.5.5/32 [110/11] via 50.0.0.2, p7p1, 17:42:48
O       6.6.6.6/32 [110/12] via 50.0.0.2, p7p1, 17:41:08
C       10.0.5.0/24 is directly connected, p9p1
C       50.0.0.0/24 is directly connected, p7p1
O       60.0.0.0/24 [110/2] via 50.0.0.2, p7p1, 17:42:48
C       127.0.0.0/8 is directly connected, lo
IP Route Table for VRF "management"
IP Route Table for VRF "VRF-1"
B       2.2.2.2/32 [20/11] via 40.0.0.1, p2p1, 01:11:29
B       3.3.3.3/32 [20/0] via 40.0.0.1, p2p1, 01:03:31
```

```
B       7.7.7.7/32 [200/0] via 6.6.6.6, 16:09:17
B       8.8.8.8/32 [200/11] via 6.6.6.6, 16:09:17
B       10.0.5.0/24 [20/0] via 40.0.0.1, p2p1, 00:00:21
B       30.0.0.0/24 [20/0] via 40.0.0.1, p2p1, 01:11:29
C       40.0.0.0/24 is directly connected, p2p1
B       70.0.0.0/24 [200/0] via 6.6.6.6, 16:09:17
B       80.0.0.0/24 [200/0] via 6.6.6.6, 16:09:17

Gateway of last resort is not set

CSC-PE1#sh ip bgp vpnv4 vrf VRF-1 label
   Network          Next Hop      In Label/Out Label
Route Distinguisher: 1:100 (Default for VRF VRF-1)
*> 2.2.2.2/32        40.0.0.1        17(p7p1)/0 (VRF-1)
*> 3.3.3.3/32        40.0.0.1        20(p7p1)/0 (VRF-1)
*>i7.7.7.7/32       6.6.6.6         0 (VRF-1)/17
*>i8.8.8.8/32       6.6.6.6         0 (VRF-1)/20
*> 10.0.5.0/24       40.0.0.1        21(p7p1)/0 (VRF-1)
* i10.0.5.0/24      6.6.6.6         0 (VRF-1)/19
*> 30.0.0.0/24       40.0.0.1        19(p7p1)/0 (VRF-1)
*> 40.0.0.0/24      0.0.0.0          18(p7p1)/aggregate(VRF-1)
*>i70.0.0.0/24      6.6.6.6         0 (VRF-1)/16
*>i80.0.0.0/24      6.6.6.6         0 (VRF-1)/18

CSC-PE1#sh mpls vrf-table
Output for IPv4 VRF table with id: 2
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active
  Owner: BGP, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0,   Protected LSP id: 0, Description: N/A
    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: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 4, owner: BGP, out intf: p2p1, out label: 0
    Nexthop addr: 40.0.0.1        cross connect ix: 4, op code: Push

 Primary FTN entry with FEC: 3.3.3.3/32, id: 4, row status: Active
  Owner: BGP, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0,   Protected LSP id: 0, Description: N/A
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 11
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: BGP, out intf: p2p1, out label: 0
    Nexthop addr: 40.0.0.1        cross connect ix: 11, op code: Push

 Primary FTN entry with FEC: 7.7.7.7/32, id: 5, row status: Active
  Owner: BGP, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0,   Protected LSP id: 0, Description: N/A
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 12, in intf: - in label: 0 out-segment ix: 12
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
```



```
      Out-segment with ix: 12, owner: BGP, out intf: p7p1, out label: 17
   Nexthop addr: 6.6.6.6        cross connect ix: 12, op code: Push and Lookup

Primary FTN entry with FEC: 8.8.8.8/32, id: 7, row status: Active
 Owner: BGP, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0,   Protected LSP id: 0, Description: N/A
   Matched bytes:142234, pkts:2363, TX bytes:0, Pushed pkts:0
    Cross connect ix: 14, in intf: - in label: 0 out-segment ix: 14
     Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 14, owner: BGP, out intf: p7p1, out label: 20
   Nexthop addr: 6.6.6.6        cross connect ix: 14, op code: Push and Lookup

Primary FTN entry with FEC: 10.0.5.0/24, id: 2, row status: Active
 Owner: BGP, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0,   Protected LSP id: 0, Description: N/A
   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, out intf: p2p1, out label: 0
   Nexthop addr: 40.0.0.1        cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 30.0.0.0/24, id: 3, row status: Active
 Owner: BGP, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0,   Protected LSP id: 0, Description: N/A
   Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
    Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 9
     Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 9, owner: BGP, out intf: p2p1, out label: 0
   Nexthop addr: 40.0.0.1        cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 70.0.0.0/24, id: 8, row status: Active
 Owner: BGP, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0,   Protected LSP id: 0, Description: N/A
   Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
    Cross connect ix: 15, in intf: - in label: 0 out-segment ix: 15
     Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 15, owner: BGP, out intf: p7p1, out label: 16
   Nexthop addr: 6.6.6.6        cross connect ix: 15, op code: Push and Lookup

Primary FTN entry with FEC: 80.0.0.0/24, id: 6, row status: Active
 Owner: BGP, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0,   Protected LSP id: 0, Description: N/A
   Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
    Cross connect ix: 13, in intf: - in label: 0 out-segment ix: 13
     Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 13, owner: BGP, out intf: p7p1, out label: 18
   Nexthop addr: 6.6.6.6        cross connect ix: 13, op code: Push and Lookup

CSC-PE1#show mpls ilm-table
Codes: > - 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
  >  30.0.0.0/24       55        19         N/A      p7p1    p2p1     40.0.0.1
LSP_DEFAULT
  >  2.2.2.2/32        53        17         N/A      p7p1    p2p1     40.0.0.1
LSP_DEFAULT
  >  40.0.0.0/24       52        16         N/A      p7p1    p2p1     0.0.0.0
LSP_DEFAULT
  >  3.3.3.3/32        65        20         N/A      p7p1    p2p1     40.0.0.1
LSP_DEFAULT
  >  10.0.5.0/24       156       21         N/A      p7p1    p2p1     40.0.0.1
LSP_DEFAULT
M4#
```

On PE1:

```
PE1#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
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.0.5.2 to network 0.0.0.0

K*      0.0.0.0/0 [0/0] via 10.0.5.2, p9p1
C       2.2.2.2/32 is directly connected, lo
O       3.3.3.3/32 [110/11] via 30.0.0.2, p7p1, 01:16:56
O E2    7.7.7.7/32 [110/1] via 30.0.0.2, p7p1, 00:05:33
O E2    8.8.8.8/32 [110/1] via 30.0.0.2, p7p1, 01:24:57
C       10.0.5.0/24 is directly connected, p9p1
C       30.0.0.0/24 is directly connected, p7p1
B       40.0.0.0/24 [200/1] via 80.0.0.1 (recursive via 30.0.0.2 ), 00:05:40
O E2    70.0.0.0/24 [110/1] via 30.0.0.2, p7p1, 01:24:57
O E2    80.0.0.0/24 [110/1] via 30.0.0.2, p7p1, 01:24:57
C       127.0.0.0/8 is directly connected, lo

On PE2:

PE2#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
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.0.5.2 to network 0.0.0.0
```



```
K*      0.0.0.0/0 [0/0] via 10.0.5.2, p9p1
O E2    2.2.2.2/32 [110/1] via 80.0.0.1, p2p1, 00:09:17
O E2    3.3.3.3/32 [110/1] via 80.0.0.1, p2p1, 00:09:17
O       7.7.7.7/32 [110/11] via 80.0.0.1, p2p1, 17:57:51
C       8.8.8.8/32 is directly connected, lo
C       10.0.5.0/24 is directly connected, p9p1
O E2    30.0.0.0/24 [110/1] via 80.0.0.1, p2p1, 00:09:17
O E2    40.0.0.0/24 [110/1] via 80.0.0.1, p2p1, 00:09:17
B       70.0.0.0/24 [200/1] via 30.0.0.2 (recursive via 80.0.0.1 ), 00:08:34
C       80.0.0.0/24 is directly connected, p2p1
C       127.0.0.0/8 is directly connected, lo
```

CHAPTER 9 MPLS Layer-3 eBGP VPN Configuration

This chapter contains configuration examples to support Virtual Private Networks (VPN) between Provider-Edge (PE) routers when they are in different Autonomous Systems (AS) using an eBGP connection.

VPN capability is extended to incorporate scenarios in which the PE routers are in different Autonomous Systems. In all cases, the connection between the PE routers is maintained using eBGP connection. EBGP-VPNs are not allowed by default.

PE to ASBR to ASBRs Using eBGP

In this example, eBGP is configured between Customer Edge (CE) and PE routers. The PE routers have an iBGP connection with Autonomous System Border Routers (ASBRs). The ASBRs are connected to each other using eBGP.

Topology

Configure other CE routers, PE routers, and ASBR according to the topology.

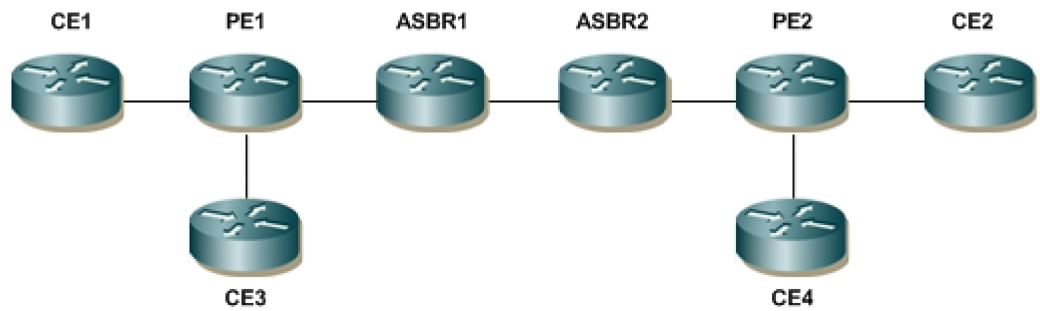


Figure 9-1: Topology of ASBRs, PEs, and CEs

CEs

`#configure terminal`	Enter Configure mode.
`(config)#int eth1`	Enter interface mode
`(config-if)#ip address 172.6.7.117/24`	Assign the IP address.
`(config-if)#exit`	Exit interface mode.
`(config)#router bgp 65001`	Define the BGP routing process with AS number `65001`.
`(config-router)#neighbor 172.6.7.116 remote-as 1`	Define the PE router as the neighbor. In this case, `172.6.7.116` is the IP address of the PE router, and `1` is the AS number.

Validation

show ip bgp neighbors, show ip bgp

PEs

`#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)#exit`	Exit VRF mode.
`(config)#int eth3`	Enter interface mode.
`(config-if)#ip vrf forwarding IPI`	Bind the interface connected to the CE router with VRF `IPI`.
`(config-if)#ip address 172.6.7.116/24`	Assign an IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router bgp 1`	Define the BGP routing process with AS number 1.
`(config-router)#neighbor 172.5.6.115 remote-as 1`	Add the ASBR as an iBGP peer: `172.5.6.115` is the ASBR IP address, and `1` is the AS number.
`(config-router)#address-family vpnv4 unicast`	Enter VPNv4 Address Family mode.
`(config-router-af)#neighbor 172.5.6.115 activate`	Activate the ASBR neighbor so that it can accept VPN routes.
`(config-router-af)#exit-address-family`	Exit VPNv4 Address Family mode.
`(config-router)#address-family ipv4 vrf IPI`	Enter the IPv4 address family for VRF `IPI`.
`(config-router-af)#neighbor 172.6.7.117 remote-as 65001`	Add the CE router as an eBGP peer: `172.6.7.117` is the IP address of the CE router, and `65001` is the AS number
`(config-router-af)#exit-address-family`	Exit IPv4 Address Family mode.
`(config-router)#exit`	Exit Router mode.

Validation

show ip bgp neighbors, show ip bgp vpnv4 all

ABSR1 and ASBR2

`#configure terminal`	Enter Configure mode.
`(config)#ip vrf IPI`	Create a new VRF named `IPI`.
`(config-vrf)#rd 1:100`	Assign the RD value as `1:100`.
`(config-vrf)#route-target both 100:200`	Import routes between RT ext-communities 100 and 200.
`(config-vrf)#exit`	Exit VRF mode.
`(config)#int eth1`	Enter interface mode.
`(config-if)#ip address 172.5.6.115/24`	Assign an IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router bgp 1`	Define the BGP routing process with AS number 1.
`(config-router)#neighbor 172.5.6.116 remote-as 1`	Add the PE router as an iBGP peer: `172.5.6.116` is the PE router IP address, and `1` is the AS number.

(config-router)#neighbor 172.4.5.114 remote-as 2	Add the remote ASBR as an eBGP peer: 172.4.5.114 is the remote ASBR IP address, and 2 is the AS number.
(config-router)#address-family vpnv4 unicast	Enter VPNv4 Address Family mode.
(config-router-af)#neighbor 172.5.6.116 activate	Activate the iBGP PE router peer to carry VPN routes.
(config-router-af)#neighbor 172.4.5.114 allow-ebgp-vpn	Enable the CLI for allowing eBGP VPNs between the two ASBRs.
(config-router-af)#neighbor 172.4.5.114 activate	Activate the eBGP ASBR to carry VPN routes.
(config-router-af)#exit-address-family	Exit IPv4 Address Family mode.
(config-router)#exit	Exit Router mode.

Validation

show ip bgp neighbors, show ip bgp vpnv4 all

PE to RR with ASBR to ASBRs by eBGP

In this example, a PE router is connected to a Route-Reflector (RR), one of whose client is an ASBR connected to other ASBRs by eBGP. This configuration is same as the scenario above (PE to ASBR to ASBRs Using eBGP), except the PE routers are clients of an RR, one of whose numerous clients is an ASBR. The ASBRs are now connected to each other using eBGP.

Topology

Configure other CE routers, PE routers, RR, and ASBR according to the topology.

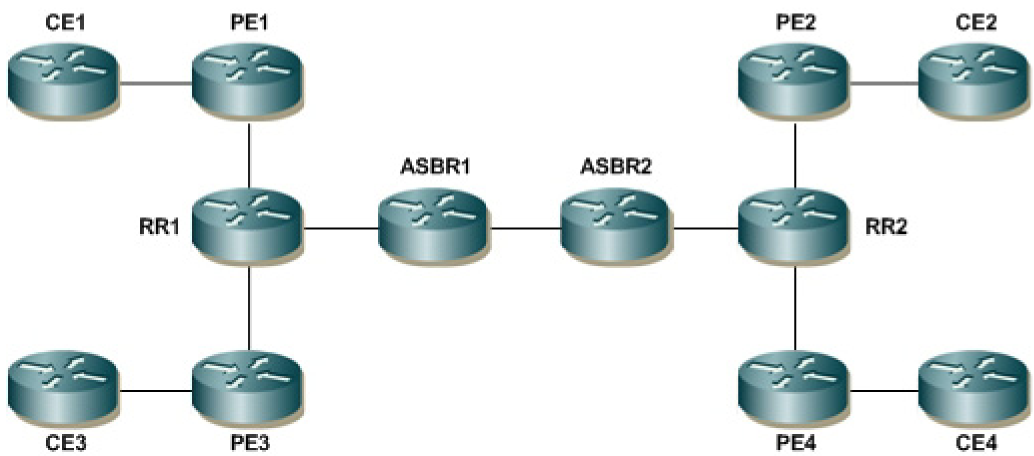


Figure 9-2: PE to RR and ASBR to ASBRs with eBGP

CE Routers

Use the same steps as in PE to ASBR to ASBRs Using eBGP.

PE Routers

Use the same steps as in PE to ASBR to ASBRs Using eBGP, except that the RR is configured as an iGBP peer, instead of the ASBR.

Route Reflectors

`#configure terminal`	Enter Configure mode.
`(config)#ip vrf IPI`	Create a new VRF named `IPI`.
`(config-vrf)#rd 1:100`	Assign the RD value as `1:100`.
`(config-vrf)#route-target both 100:200`	Import routes between RT ext-communities 100 and 200.
`(config-vrf)#exit`	Exit VRF mode.
`(config)#int eth1`	Enter interface mode.
`(config-if)#ip address 172.4.5.114/24`	Assign an IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router bgp 1`	Define the BGP routing process with AS number 1.
`(config-router)#neighbor 172.5.6.116 remote-as 1`	Add the PE router as an iBGP peer: `172.5.6.116` is the PE router IP address, and `1` is the AS number.
`(config-router)#neighbor 172.4.5.114 remote-as 1`	Add the ASBR as an iBGP peer: `172.4.5.114` is the ASBR IP address, and `1` is the AS number.
`(config-router)#address-family vpnv4 unicast`	Enter VPNv4 Address Family mode.
`(config-router-af)#neighbor 172.5.6.116 activate`	Activate the PE router to carry VPN routes.
`(config-router-af)#neighbor 172.5.6.116 route-reflector-client`	Add the PE router as a route-reflector-client.
`(config-router-af)#neighbor 172.4.5.114 activate`	Activate the ASBR to carry VPN routes.
`(config-router-af)#neighbor 172.4.5.114 route-reflector-client`	Add the ASBR as a route-reflector-client.
`(config-router-af)#exit-address-family`	Exit IPv4 Address Family mode.
`(config-router)#exit`	Exit Router mode.

ASBRs

Use the same configuration steps as in PE to ASBR to ASBRs Using eBGP, except that the ASBR is configured as an iGBP peer, instead of an RR.

Validation

show ip bgp neighbors, show ip bgp vpnv4 all

Connect PEs Using eBGP Multihop

In this example, PE routers are directly connected to each other using an eBGP multihop connection.

EBGP is configured between CE-PE routers. PE routers are configured to have an eBGP multihop connection between them. To make the multihop connection work, an IGP protocol must be run between PE1-P-PE2.

Topology

Configure other CE and PE routers according to the topology. The P routers should only have an IGP protocol (OSPF, in this case) configuration.

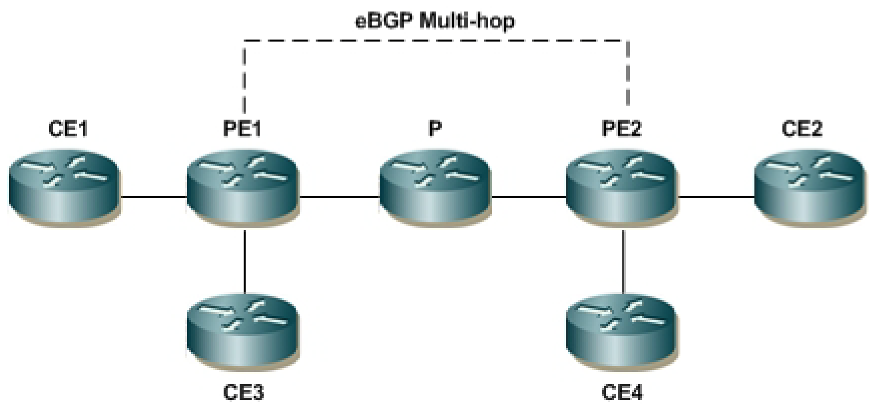


Figure 9-3: Connecting PEs Using eBGP Multihop

CE Routers

`#configure terminal`	Enter Configure mode.
`(config)#int eth1`	Enter interface mode
`(config-if)#ip address 172.6.7.117/24`	Assign the IP address.
`(config-if)#exit`	Exit interface mode.
`(config)#router bgp 65001`	Define the BGP routing process with AS number `65001`.
`(config-router)#neighbor 172.6.7.116 remote-as 1`	Define the PE router as the neighbor. In this case `172.6.7.116` is the IP address of the PE router and `1` is the AS number.

Validation

show ip bgp neighbors, show ip bgp

PE Routers

`#configure terminal`	Enter Configure mode.
`(config)#ip vrf IPI`	Create a new VRF named `IPI`.
`(config-vrf)#rd 1:100`	Assign the RD value as `1:100`.
`(config-vrf)#route-target both 100:200`	Import routes between RT ext-communities 100 and 200.
`(config-vrf)#exit`	Exit VRF mode.
`(config)#int eth3`	Enter interface mode.
`(config-if)#ip vrf forwarding IPI`	Bind the interface connected to the CE router with VRF `IPI`.

`(config-if)#ip address 172.6.7.116/24`	Assign an IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 1`	Define the OSPF routing process.
`(config-router)#network 172.5.6.0/24 area 0`	Advertise the network between the PE router with the P router, so the multihop connection can come up.
`(config-router)#exit`	Exit the OSPF routing process.
`(config)#router bgp 1`	Define the BGP process with AS number 1.
`(config-router)#neighbor 172.4.5.114 remote-as 2`	Define the remote PE router as the neighbor. In this case, `172.4.5.114` is the IP address of the remote PE router, and `2` is the AS number
`(config-router)#neighbor 172.4.5.114 ebgp-multihop 255`	Assign the remote PE router as an eBGP-multihop peer.
`(config-router)#address-family vpnv4 unicast`	Enter VPNv4 Address Family mode.
`(config-router-af)#neighbor 172.4.5.114 allow-ebgp-vpn`	Configure the remote PE router to allow eBGP VPNs.
`(config-router-af)#neighbor 172.4.5.114 activate`	Activate the remote PE router so that it can accept VPN routes.
`(config-router-af)#exit-address-family`	Exit VPNv4 Address Family mode.
`(config-router)#address-family ipv4 vrf IPI`	Enter the IPv4 address family for VRF `IPI`.
`(config-router-af)#neighbor 172.6.7.117 remote-as 65001`	Define the CE router as a neighbor: `172.6.7.117` is the IP address of the CE router, and `65001` is the AS number
`(config-router-af)#exit-address-family`	Exit IPv4 Address Family mode.
`(config-router)#exit`	Exit Router mode.

Validation

show ip bgp neighbors, show ip bgp vpnv4 all

Connect PEs to RRs to RRs Using eBGP Multihop

In this example, PE routers are connected to Route-Reflectors (RRs), which are connected to other RRs using an eBGP-multihop connection.

This configuration is same as the previous scenario (Connect PEs Using eBGP Multihop), except the PE routers are connected to RRs using an iBGP connection. EBGP Multihop connections are present between the RRs only.

Topology

Configure the CE routers, PE routers, and RRs according to the topology. The P routers should only have an IGP protocol (OSPF, in this case) configuration.

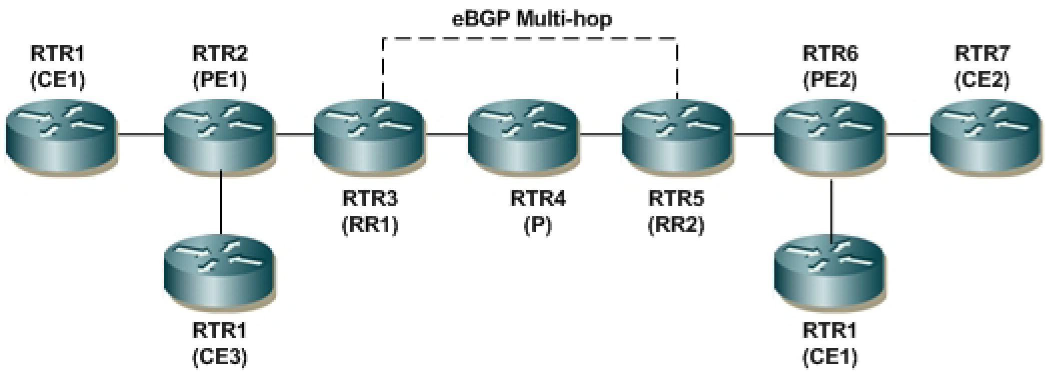


Figure 9-4: Connecting PEs to Route Reflectors Using eBGP Multihop

CE Routers

Same as the scenario for Connect PEs Using eBGP Multihop.

PE Routers

Same as the scenario for Connect PEs Using eBGP Multihop, except PE routers have only iBGP connections with the RR.

Route Reflectors

`#configure terminal`	Enter Configure mode.
`(config)#ip vrf IPI`	Create a new VRF named `IPI`.
`(config-vrf)#rd 1:100`	Assign the RD value as `1:100`.
`(config-vrf)#route-target both 100:200`	Import routes between RT ext-communities 100 and 200.
`(config-vrf)#exit`	Exit VRF mode.
`(config)#int eth1`	Enter interface mode.
`(config-if)#ip address 172.5.6.115/24`	Assign an IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router bgp 1`	Define the BGP routing process with AS number 1.
`(config-router)#neighbor 172.5.6.116 remote-as 1`	Add the PE router as an iBGP peer: `172.5.6.116` is the PE router IP address, and `1` is the AS number.
`(config-router)#neighbor 172.3.4.113 remote-as 2`	Add the remote RR as an iBGP peer: `172.3.4.113` is the IP address of the remote eBGP peer, and `2` is the AS number.
`(config-router)#neighbor 172.3.4.113 ebgp-multihop 255`	Assign the remote RR router as an eBGP multihop peer.
`(config-router)#address-family vpnv4 unicast`	Enter VPNv4 Address Family mode.
`(config-router-af)#neighbor 172.3.4.113 allow-ebgp-vpn`	Configure the remote RR to allow EBGP VPNs.
`(config-router-af)#neighbor 72.3.4.113 activate`	Activate the remote RR to carry VPN routes.

`(config-router-af)#neighbor 172.5.6.116 activate`	Activate the PE router to carry VPN routes.
`(config-router-af)#neighbor 172.5.6.116 route-reflector-client`	Add the PE router as a route-reflector-client.
`(config-router-af)#exit-address-family`	Exit IPv4 Address Family mode.
`(config-router)#exit`	Exit Router mode.
`(config)#router ospf 1`	Define the OSPF routing process.
`(config-router)#network 172.4.5.0/24 area 0`	Advertise the network between the PE router with the P router, so the multihop connection can come up.
`(config-router)#exit`	Exit the OSPF routing process.

Validation

show ip bgp neighbors, show ip bgp vpnv4 all

CHAPTER 10 VPLS Configuration

This chapter contains configurations for Virtual Private LAN Service (VPLS).

For details about the commands, see the *Label Distribution Protocol Command Reference*.

Overview

VPLS can be configured in two different ways:

- VPLS Mesh
- VPLS Spoke

The examples show the minimum configuration required for enabling a VPLS Mesh peer between PE1, PE2, and PE4 and a VLPS Mesh-Spoke peer between PE1 and MTU-r.

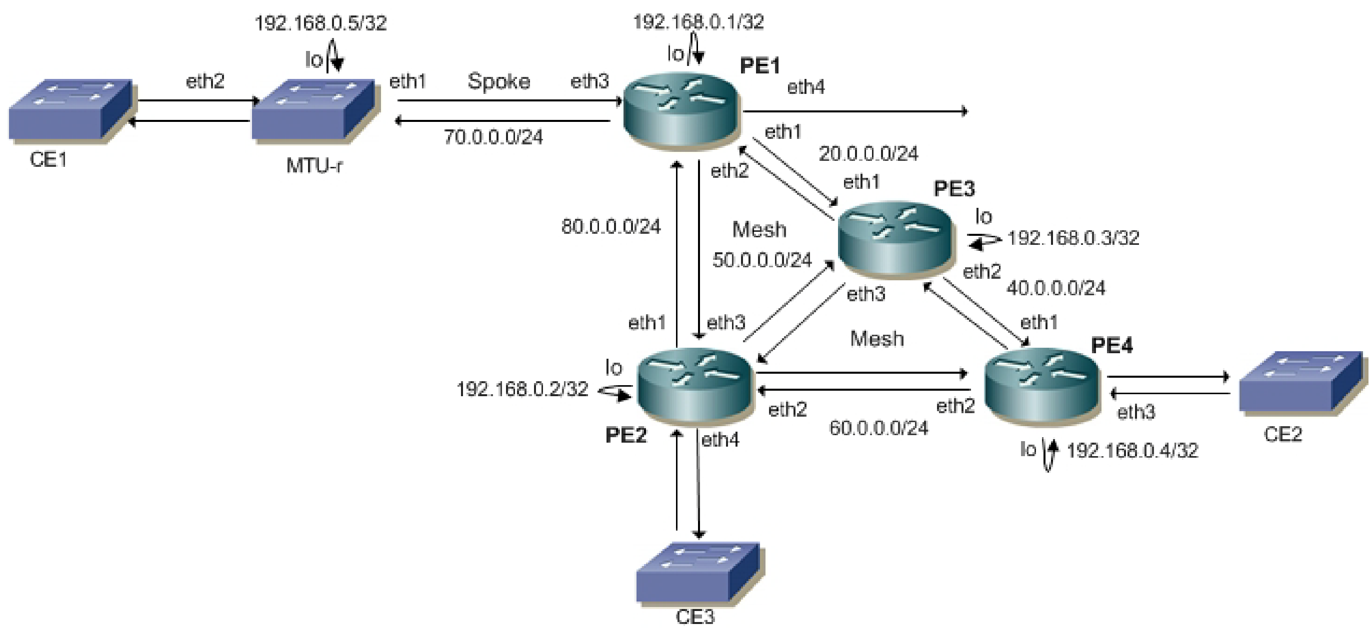


Figure 10-1: VPLS Mesh and Spoke Peers

The Virtual Circuit (VC) configuration process can be divided into the following steps:

1. Configuring the VPLS Mesh on PE4 and PE2
2. Configuring the VPLS Mesh and Spoke on PE1 and MTU-r
3. Configuring MTU-r
4. Setting up LSPs

Detailed steps are listed below.

Configure VPLS Mesh

PE4 - NSM

`#configure terminal`	Enter Configure mode.
`(config)#mpls vpls T1 10`	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (`T1`) and VPLS ID (`10`).

Note: The following step applies only if the VPLS is to be configured as VLAN. By default, the VPLS type is Ethernet.

`(config-vpls)#vpls-type vlan`	Configure the VPLS as VLAN.
`(config-vpls)#exit`	Exit VPLS mode.
`(config-if)#bridge 1 protocol ieee vlan-bridge`	Configure bridge
`(config)#interface eth3`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode. (VPLS can be bound only on the Layer-2 port.)
`(config-if)#bridge-group 1`	Configure bridge group
`(config-if)#switchport mode access`	For Ethernet based vpls this config applies. For vlan based vpls, should configure switchport mode trunk

Note: The next step applies only if the VPLS is configured as Ethernet. If the VPLS is configured as VLAN, ignore the next step, and proceed to the step that follows.

`(config-if)#mpls-vpls T1`	Associate an interface with the VPLS instance for port binding by specifying the VPLS name on the interface.Repeat this step for all interfaces connected towards the CEs which have to be associated with this VPLS instance.

Note: The next step applies only if the VPLS is to be configured as VLAN.

`(config-if)#mpls-vpls T1 vlan 2`	Associate an interface with the VPLS instance for VLAN binding by specifying the VPLS name on the interface and the VLAN ID. Repeat this step for all interfaces connected to customer edge devices associated with this VPLS instance.

Note: One VPLS can be bound to multiple customer interfaces; multiple VPLS can be bound to the same interface with VLAN encapsulation.

`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on interface `eth1`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on interface `eth2`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Enter interface mode.

`(config-if)#ip address 192.168.0.4/32`	Set the IP address of the loopback interface to `192.168.0.4/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls vpls T1 10`	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (`T1`) and VPLS ID (`10`).

Note: To enable VPLS signaling via LDP, complete the commands that follow.

`(config-vpls)#signaling ldp`	Enter VPLS signaling LDP mode.
`(config-vpls-sig)#vpls-peer 192.168.0.1`	Create a VPLS VC with core routers (PE1 and PE2) to which the mesh VC is to be associated by configuring the IP address of the peer nodes.
`(config-vpls-sig)#vpls-peer 192.168.0.2`	
`(config-vpls-sig)#exit`	Exit signaling LDP mode.

PE4 - LDP

`(config)#router ldp`	Enter Router mode.
`(config-router)#transport-address ipv4 192.168.0.4 0`	Configure the transport address for a label space by binding the address to a loopback address.
`(config-router)#targeted-peer ipv4 192.168.0.1`	Specify the peers (PE1 and PE2) as targeted peers to enable an LDP session between non-directly connected peers.
`(config-router)#targeted-peer ipv4 192.168.0.2`	
`(config-router)#exit`	Exit Router mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP on the specified interface (`eth1`).
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP on the specified interface (`eth2`).
`(config-if)#exit`	Exit interface mode.

PE4 - RSVP-TE

Note: For a DiffServ-enabled build, DiffServ configuration is required.

`(config)#router rsvp`	Enter Router mode.
`(config-router)#exit`	Exit Router mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#enable-rsvp`	Enable RSVP-TE on the specified interface (`eth1`).
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#enable-rsvp`	Enable RSVP-TE on the specified interface (`eth2`).
`(config-if)#exit`	Exit interface mode.

PE4 - OSPF

(config)#router ospf 110	Configure the OSPF routing process, and specify the process ID.
(config-router)#network 192.168.0.4/32 area 0	Define the interfaces on which OSPF runs, and designate the backbone area 0.
(config-router)#network 40.0.0.0/24 area 0	
(config-router)#network 60.0.0.0/24 area 0	
(config-router)#exit	Exit Router mode.

PE3 - NSM

(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.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 192.168.0.3/32	Set the IP address of the loopback interface to 192.168.0.3/32.
(config-if)#exit	Exit interface mode.

PE3 - LDP

(config)#router ldp	Enter Router mode.
(config-router)#transport-address ipv4 192.168.0.3 0	Configure the transport address for a label space by binding the address to a loopback address.
(config-router)#exit	Exit Router mode.
(config)#interface eth1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on the specified interface (eth1).
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on the specified interface (eth2).
(config-if)#exit	Exit interface mode.

PE3 - RSVP-TE

(config)#router rsvp	Enter Router mode.
(config-router)#exit	Exit Router mode.

(config)#interface eth1	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP-TE on the specified interface (eth1).
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP-TE on the specified interface (eth2).
(config-if)#exit	Exit interface mode.

PE3 - OSPF

(config)#router ospf 110	Configure the OSPF routing process, and specify the process ID.
(config-router)#network 192.168.0.3/32 area 0	Define the interfaces on which OSPF runs, and specify the backbone area 0.
(config-router)#network 20.0.0.0/24 area 0	
(config-router)#network 40.0.0.0/24 area 0	
(config-router)#exit	Exit Router mode.

PE2 - NSM

(config)#mpls vpls T1 10	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (T1) and VPLS ID (10).
(config-vpls)#exit	Exit VPLS mode.
(config)#bridge 1 protocol ieee vlan-bridge	Configure bridge.
(config)#interface eth3	Enter interface mode.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#bridge-group 1	Configure bridge group
(config-if)#switchport mode access	Configure switchport mode as access
(config-if)#mpls-vpls T1	Associate an interface with the VPLS instance for port binding by specifying the VPLS name on the interface. Repeat this step for all interfaces towards the CEs which have to be associated with this VPLS instance.
(config-if)#exit	Exit interface mode.
(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.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 192.168.0.2/32	Set the IP address of the loopback interface to 192.168.0.2/32.

(config-if)#exit	Exit interface mode.
(config)#mpls vpls T1 10	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (T1) and VPLS ID (10).

Note: To enable VPLS signaling via LDP, complete the commands that follow.

(config-vpls)#signaling ldp	Enter the signaling LDP mode.
(config-vpls-sig)#vpls-peer 192.168.0.1	Create a VPLS VC with core routers (PE1 and PE2) to which the mesh VC is to be associated by configuring the IP address of the peer nodes.
(config-vpls-sig)#vpls-peer 192.168.0.4	
(config-vpls-sig)#exit	Exit signaling LDP mode.

PE2 - LDP

(config)#router ldp	Enter Router mode.
(config-router)#transport-address ipv4 192.168.0.2 0	Configure the transport address for a label space by binding the address to a loopback address.
(config-router)#targeted-peer ipv4 192.168.0.1	Specify the peers (PE1 and PE2) as targeted peers to enable an LDP session between non-directly connected peers.
(config-router)#targeted-peer ipv4 192.168.0.4	
(config-router)#exit	Exit Router mode.
(config)#interface eth1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on the specified interface (eth1).
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on the specified interface (eth2).
(config-if)#exit	Exit interface mode.

PE2 - RSVP-TE

(config)#router rsvp	Enter Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface eth1	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP-TE on the specified interface (eth1).
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP-TE on the specified interface (eth2).
(config-if)#exit	Exit interface mode.

PE2 - OSPF

`(config)#router ospf 110`	Configure the OSPF routing process, and specify the process ID.
`(config-router)#network 192.168.0.2/32 area 0`	Define the interfaces on which OSPF runs, and specify the backbone area 0.
`(config-router)#network 60.0.0.0/24 area 0`	
`(config-router)#network 80.0.0.0/24 area 0`	
`(config-router)#exit`	Exit Router mode.

Configure VPLS Mesh and Spoke on PE1 and MTU-r

PE1 - NSM

`(config)#mpls l2-circuit pe1-mtur 20 192.168.0.5`	Create an instance of Layer-2 VC by specifying the name (`pe1-mtur`) and ID (`20`) of the VC and the IP address of the VC end-point (MTU-r).
`(config)#mpls vpls T1 10`	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (`T1`) and VPLS ID (`10`).
`(config-vpls)#vpls-vc pe1-mtur`	Bind an instance of MPLS L-2 VC to VPLS by specifying the name of the L-2 VC (`pe1-mtur`) to be added to this VPLS instance.
`(config-vpls)#exit`	Exit VPLS mode.
`(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.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on interface `eth3`.
`(config-if)#exit`	Exit interface mode.
`(config)#bridge 1 protocol ieee vlan-bridge`	Enter interface mode.
`(config)#interface eth4`	Enter Interface Mode
`(config-if)#switchport`	Switch to Layer-2 mode
`(config)#bridge-group 1`	Configure bridge-group
`(config)#switchport mode access`	Configure switchport mode as access
`(config-if)#mpls-vpls T1`	Associate an interface with the VPLS instance for port binding by specifying the VPLS name on the interface. Repeat this step for all interfaces towards the CEs which have to be associated with this VPLS instance
`(config-if)#exit`	Exit interface mode.

(config)#interface lo	Enter interface mode.
(config-if)#ip address 192.168.0.1/32	Set the IP address of the loopback interface to 192.168.0.1/32.
(config-if)#exit	Exit interface mode.
(config)#mpls vpls T1 10	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (T1) and VPLS ID (10).

Note: To enable VPLS signaling via LDP, complete the commands that follow.

(config-vpls)#signaling ldp	Enter the signaling LDP mode.
(config-vpls-sig)#vpls-peer 192.168.0.2	Create a VPLS VC with core routers (PE1 and PE2) to which the mesh VC is to be associated by configuring the IP address of the peer nodes.
(config-vpls-sig)#vpls-peer 192.168.0.4	
(config-vpls-sig)#exit	Exit signaling LDP mode.

PE1 - LDP

(config)#router ldp	Enter Router mode.
(config-router)#transport-address ipv4 192.168.0.1 0	Configure the transport address for a label space by binding the address to a loopback address.
(config-router)#targeted-peer ipv4 192.168.0.2	Specify the peers (PE2, PE4, and PE5) as targeted peers to enable an LDP session between non-directly connected peers.
(config-router)#targeted-peer ipv4 192.168.0.4	
(config-router)#targeted-peer ipv4 192.168.0.5	
(config-router)#exit	Exit Router mode.
(config)#interface eth1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on the specified interface (eth1).
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on the specified interface (eth2).
(config-if)#exit	Exit interface mode.
(config)#interface eth3	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on the specified interface (eth3).
(config-if)#exit	Exit interface mode.

PE1 - RSVP-TE

(config)#router rsvp	Enter Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface eth1	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP-TE on the specified interface (eth1).
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP-TE on the specified interface (eth2).

`(config-if)#exit`	Exit interface mode.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#enable-rsvp`	Enable RSVP-TE on the specified interface (`eth3`).
`(config-if)#exit`	Exit interface mode.

PE1 - OSPF

`(config)#router ospf 110`	Configure the OSPF routing process, and specify the process ID.
`(config-router)#network 192.168.0.1/32 area 0`	Define the interfaces on which OSPF runs, and specify the backbone area 0.
`(config-router)#network 20.0.0.0/24 area 0`	
`(config-router)#network 70.0.0.0/24 area 0`	
`(config-router)#network 80.0.0.0/24 area 0`	
`(config-router)#exit`	Exit Router mode.

MTU-r - NSM

`(config)#mpls l2-circuit pe1-mtur 20 192.168.0.1`	Create an instance of Layer-2 VC by specifying the name (`pe1-mtur`) and ID (`20`) of the VC and the IP address of the VC end-point (PE1).
`(config)#bridge 1 protocol ieee vlan-bridge`	Enter interface mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode. (MPLS l2 circuit can be bound only on the Layer-2 port.)
`(config)#bridge-group 1`	Configure bridge-group
`(config)#switchport mode access`	Configure switchport mode as access
`(config-if)#mpls-l2-circuit pe1-mtur`	Bind an interface (`eth2`) with the Layer-2 VC created in the Configure mode by specifying the VC name (`pe1-mtur`) and type.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on interface `eth1`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 192.168.0.5/32`	Set the IP address of the loopback interface to `192.168.0.5/32`.
`(config-if)#exit`	Exit interface mode.

MTU-r - LDP

`(config)#router ldp`	Enter Router mode.
`(config-router)#transport-address ipv4 192.168.0.5 0`	Configure the transport address for a label space by binding the address to a loopback address.

`(config-router)#targeted-peer ipv4 192.168.0.1`	Specify the peer (PE1) as targeted a peer to enable an LDP session between non-directly connected peers.
`(config-router)#exit`	Exit Router mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP on the specified interface (`eth1`).
`(config-if)#exit`	Exit interface mode.

MTU-r - RSVP-TE

`(config)#router rsvp`	Enter Router mode.
`(config-router)#exit`	Exit Router mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#enable-rsvp`	Enable RSVP-TE on the specified interface (`eth1`).
`(config-if)#exit`	Exit interface mode.

MTU-r - OSPF

`(config)#router ospf 110`	Configure the OSPF routing process, and specify the process ID.
`(config-router)#network 192.168.0.5/32 area 0`	Define the interfaces on which OSPF runs, and specify the backbone area 0.
`(config-router)#network 70.0.0.0/24 area 0`	
`(config-router)#exit`	Exit Router mode.

Set Up LSPs

PE4

`#configure terminal`	Enter Configure mode.
`(config)#rsvp-trunk T41`	Create RSVP trunk `T41` and enter Trunk mode.
`(config-trunk)#to 192.168.0.1`	Specify the IPv4 egress (destination point) for the LSP.
`(config-trunk)#exit`	Exit Trunk mode.
`(config)#rsvp-trunk T42`	Create RSVP trunk `T42`, and enter Trunk mode.
`(config-trunk)#to 192.168.0.2`	Specify the IPv4 egress (destination point) for the LSP.
`(config-trunk)#exit`	Exit Trunk mode.

PE2

`#configure terminal`	Enter Configure mode.
`(config)#rsvp-trunk T21`	Create an RSVP trunk `T21` and enter Trunk mode.
`(config-trunk)#to 192.168.0.1`	Specify the IPv4 egress (destination point) for the LSP.
`(config-trunk)#exit`	Exit Trunk mode.
`(config)#rsvp-trunk T24`	Create RSVP trunk `T24`, and enter Trunk mode.

(config-trunk)#to 192.168.0.4	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#exit	Exit Trunk mode.

PE1

#configure terminal	Enter Configure mode.
(config)#rsvp-trunk T12	Create RSVP trunk T12, and enter Trunk mode.
(config-trunk)#to 192.168.0.2	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#exit	Exit Trunk mode.
(config)#rsvp-trunk T14	Create RSVP trunk T14 and enter Trunk mode.
(config-trunk)#to 192.168.0.4	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#exit	Exit Trunk mode.
(config)#rsvp-trunk T15	Create RSVP trunk T15, and enter Trunk mode.
(config-trunk)#to 192.168.0.5	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#exit	Exit Trunk mode.

MTU-r

#configure terminal	Enter Configure mode.
(config)#rsvp-trunk T51	Create RSVP trunk T51 and enter Trunk mode.
(config-trunk)#to 192.168.0.1	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#exit	Exit Trunk mode.

Validation for PE1

Verify VPLS Session

```
PE1#sh mpls vpls
Name          VPLS-ID     Type              MPeers    SPeers    SIG-Protocol
Learning
T1            10          Ethernet          2         1         LDP
Enabled
PE1#

PE1#sh mpls vpls detail
Virtual Private LAN Service Instance: T1, ID: 10
 SIG-Protocol: LDP
 Learning: Enabled
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 Configured interfaces: eth4
 Mesh Peers:  192.168.0.2 (Up)
              192.168.0.4 (Up)
 Spoke Peers: pe1-mtur (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
```

```
10          192.168.0.2       3              53125      eth2            53120
1/Up       2          LDP
10          192.168.0.4       53121          53121      eth1            52487
2/Up       3          LDP
PE1#
```

Verify VPLS Mesh Spoke

```
PE1#sh mpls vpls spoke
VPLS-ID    Virtual Circuit  Tunnel-Label In-Label   Network-Intf   Out-Label
Lkps/St
10         pe1-mtur         3            53120      eth3           53120
1/Up
PE1#
```

Validation for the Number of Configured VPLS Instances

This example shows number of configured VPLS instances.

```
#show mpls vpls count
VPLS instances : 25000

#show ldp vpls count
VPLS instances : 25000
```

CHAPTER 11 Static VPLS Configuration

This chapter includes step-by-step configurations for Static VPLS. It also contains an overview of the concepts of Static VPLS.

See the *Network Services Module Command Reference* for details about the commands used.

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

Static VPLS can be configured in two different ways:

- VPLS-Peer
- VPLS-Spoke

In the following examples, VPLS (v1) is configured on PE2 with Static VLPS-Peers PE1 and PE3 using static LSPs; Static VPLS-Spoke (t1) is configured with a Static VC between PE2 and PE4 using LDP LSP.

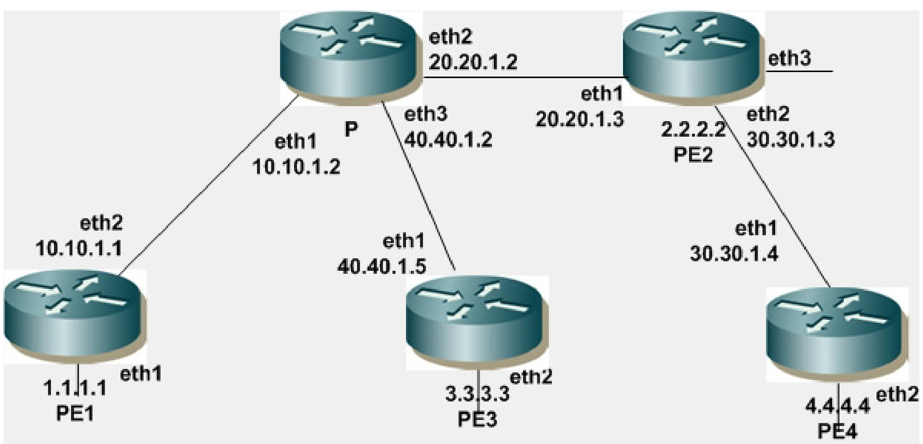


Figure 11-1: Static Virtual Private LAN Service Topology

PE1

`#configure terminal`	Enter configure mode.
`(config)#mpls ftn-entry tunnel-id 11 2.2.2.2/32 101 10.10.1.2 eth2 primary`	Configure MPLS FTN entry for the creation of a static LSP to PE2.
`(config)#mpls ftn-entry tunnel-id 22 3.3.3.3/32 301 10.10.1.2 eth2 primary`	Configure MPLS FTN entry for the creation of a static LSP to PE3.
`(config)#mpls ilm-entry 202 eth2 pop`	Configure MPLS ILM entry for the creation of a static LSP to PE2.
`(config)#mpls ilm-entry 402 eth2 pop`	Configure MPLS ILM entry for the creation of a static LSP to PE3.
`(config)#mpls vpls v1 100`	Configure VPLS `v1` with ID `100` on PE1.
`(config-vpls)#vpls-peer 2.2.2.2 tunnel-id 11 manual`	Configure PE2 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 PE3 as a manual VPLS peer using the static LSP tunnel ID `22`.
`(config-vpls)#exit`	Exit Configure VPLS mode.
`(config)#vpls fib-entry 100 peer 2.2.2.2 1000 eth2 2000`	Configure VPLS FIB entry for VPLS peer PE2.
`(config)#vpls fib-entry 100 peer 3.3.3.3 3000 eth2 4000`	Configure VPLS FIB entry for VPLS peer PE3.
`(config)#bridge 1 protocol ieee vlan-bridge`	Specify `bridge 1` as VLAN.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#label-switching`	Configure label switching
`(config)#interface eth1`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#bridge-group 1`	Configure bridge-group.
`(config-if)#switchport mode access`	Set the switching characteristics of the Interface to Access mode.
`(config-if)#mpls-vpls v1`	Bind the VPLS to the Access Interface.

P

`#configure terminal`	Enter Configure mode.
`(config)#mpls ilm-entry 101 eth1 swap 102 eth2 20.20.1.3 2.2.2.2/32`	Configure MPLS ILM entry for the static LSP from PE1 to PE2.
`(config)#mpls ilm-entry 301 eth1 swap 302 eth3 40.40.1.5 3.3.3.3/32`	Configure MPLS ILM entry for the static LSP from PE1 to PE3.
`(config)#mpls ilm-entry 201 eth2 swap 202 eth1 10.10.1.1 1.1.1.1/32`	Configure MPLS ILM entry for the static LSP from PE2 to PE1.
`(config)#mpls ilm-entry 401 eth2 swap 402 eth3 40.40.1.5 3.3.3.3/32`	Configure MPLS ILM entry for the static LSP from PE2 to PE3.

`(config)#mpls ilm-entry 501 eth3 swap 502 eth2 20.20.1.3 2.2.2.2/32`	Configure MPLS ILM entry for the static LSP from PE2 to PE3.
`(config)#mpls ilm-entry 601 eth2 swap 602 eth3 40.40.1.5 3.3.3.3/32`	Configure MPLS ILM entry for the static LSP from PE2 to PE3.

PE2

`#configure terminal`	Enter Configure mode.
`#mpls l2-circuit t1 10 4.4.4.4 manual`	Configure Virtual Circuit
`(config)# mpls ftn-entry tunnel-id 11 1.1.1.1/32 201 20.20.1.2 eth1 primary`	Configure MPLS FTN entry for the creation of a static LSP to PE1, and designate `eth1` as primary.
`(config)#mpls ftn-entry tunnel-id 33 3.3.3.3/32 601 20.20.1.2 eth1 primary`	Configure MPLS FTN entry with for the creation of a static LSP to PE3, and designate `eth1` as primary.
`(config)#mpls ilm-entry 102 eth2 pop`	Configure MPLS ILM entry for the creation of a static LSP to PE1.
`(config)#mpls ilm-entry 502 eth2 pop`	Configure MPLS ILM entry for the creation of a static LSP to PE3.
`(config)#mpls vpls v1 100`	Configure VPLS `v1` with ID `100` on PE2.
`(config-vpls)#vpls-peer 1.1.1.1 tunnel-id 11 manual`	Configure PE1 as a manual VPLS peer using static LSP tunnel ID
`(config-vpls)#vpls-peer 3.3.3.3 tunnel-id 33 manual`	Configure PE3 as a manual VPLS peer using static LSP tunnel ID
`(config-vpls)#vpls-vc t1 ethernet`	Configure `t1` as VPLS spoke.
`(config-vpls)#exit`	Exit Configure VPLS mode.
`(config)#vpls fib-entry 100 peer 1.1.1.1 2000 eth1 1000`	Configure VPLS FIB entry for VPLS peer PE1.
`(config)#vpls fib-entry 100 peer 3.3.3.3 5000 eth1 6000`	Configure VPLS FIB entry for VPLS peer PE3.
`(config)#vpls fib-entry 100 spoke-vc t1 7000 eth2 8000`	Configure VPLS FIB entry for VPLS spoke `t1`.
`(config)#bridge 1 protocol ieee vlan-bridge`	Specify `bridge 1` as VLAN.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#bridge-group 1`	Configure bridge-group.
`(config-if)#switchport mode access`	Set the switching characteristics of this interface to access mode.
`(config-if)#mpls-vpls v1`	Bind the VPLS to the Access Interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter Router LDP mode.
`(config-router)#transport-address ipv4 2.2.2.2`	Configure transport-address on PE2.
`(config-router)#exit`	Exit Router LDP mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#label-switching`	Configure label switching
`(config)#interface eth2`	Enter interface mode.

(config-if)#label-switching	Enable label-switching on eth2.
(config-if)#enable-ldp ipv4	Enable LDP on eth2.
(config-if)#exit	Exit interface mode.

PE3

#configure terminal	Enter configure mode.
(config)#mpls ftn-entry tunnel-id 22 1.1.1.1/32 401 40.40.1.2 eth1 primary	Configure MPLS FTN entry for the creation of a static LSP to PE1.
(config)#mpls ftn-entry tunnel-id 33 2.2.2.2/32 501 20.20.1.2 eth1 primary	Configure MPLS FTN entry for the creation of a static LSP to PE2.
(config)#mpls ilm-entry 302 eth2 pop	Configure MPLS ILM entry for the creation of a static LSP to PE1.
(config)#mpls ilm-entry 602 eth2 pop	Configure MPLS ILM entry for the creation of a static LSP to PE2.
(config)#mpls vpls v1 100	Configure VPLS v1 with ID 100 on PE3.
(config-vpls)#vpls-peer 1.1.1.1 tunnel-id 22 manual	Configure PE1 as a manual VPLS peer using static LSP tunnel ID 55.
(config-vpls)#vpls-peer 2.2.2.2 tunnel-id 33 manual	Configure PE2 as a manual VPLS peer using static LSP tunnel ID 66.
(config-vpls)#exit	Exit Configure VPLS mode.
(config)#vpls fib-entry 100 peer 1.1.1.1 4000 eth1 3000	Configure VPLS FIB entry for VPLS peer PE1.
(config)#vpls fib-entry 100 peer 2.2.2.2 6000 eth1 5000	Configure VPLS FIB entry for VPLS peer PE2.
(config)#bridge 1 protocol ieee vlan-bridge	Specify bridge 1 as VLAN.
(config)#interface eth1	Enter interface mode.
(config-if)#label-switching	Configure label switching
(config)#interface eth2	Enter interface mode.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#bridge-group 1	Configure bridge-group.
(config-if)#switchport mode access	Set the switching characteristics of eth2 to access mode.
(config-if)#mpls-vpls v1	Bind the VPLS to the Access Interface.
(config-if)#exit	Exit interface mode.

PE4

#configure terminal	Enter Configure mode.
(config)#router ldp	Enter Router LDP mode.
(config-router)#transport-address ipv4 4.4.4.4	Configure transport-address on PE4.
(config-router)#exit	Exit Router LDP mode.
(config)#interface eth1	Enter interface mode.

`(config-if)#label-switching`	Enable `label-switching` on the provider interface of PE1.
`(config-if)#enable-ldp ipv4`	Enable LDP on the provider interface of PE1.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls l2-circuit t1 10 2.2.2.2 manual`	Configure manual VC named `t1` with PW-ID of `10`.
`(config)#mpls l2-circuit-fib-entry 10 8000 7000 2.2.2.2 eth1 eth2`	Configure `mpls l2-circuit` FIB entry for manual VC.
`(config)#bridge 1 protocol ieee vlan-bridge`	Specify `bridge 1` as VLAN.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#bridge-group 1`	Configure bridge-group.
`(config-if)#switchport mode access`	Set the switching characteristics of `eth2` to access mode.
`(config-if)#mpls-l2-circuit t1`	Bind the VC to the Access Interface.

Validation

Enter the commands listed in the sections below to confirm the configurations.

Verify VPLS Session on PE2

```
#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 100
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 Configured interfaces: eth3
 Mesh Peers:  1.1.1.1 (Up)
              3.3.3.3 (Up)
 Spoke Peers: t1 (Up)
```

Verify VPLS Peer

```
#show mpls vpls mesh
VPLS-ID   Peer Addr  Tunnel-Info In-Label   Network-Intf   Out-Label  Lkps/St   PW-INDEX
100       1.1.1.1      201          2000       eth1           1000         2/Up    1
100       3.3.3.3      601          5000       eth3           6000         2/Up    2
```

Verify VPLS Spoke

```
#show mpls vpls spoke
VPLS-ID  Virtual Circuit   Tunnel-info In-Label   Network-Intf   Out-Label  Lkps/St
100      t1                3           7000       eth2           8000          2/Up
```

Remove Configurations

Folow these steps to remove VPLS peer and VPLS spoke FIB entries from router PE2.

`#configure terminal`	Enter configure mode.
`(config)#no vpls fib-entry 100 peer 1.1.1.1`	Remove VPLS FIB for VPLS peer PE1.

`(config)#no vpls fib-entry 100 peer 3.3.3.3`	Remove VPLS FIB for VPLS peer PE3.
`(config)#no vpls fib-entry 100 spoke-vc t1`	Remove VPLS FIB for VPLS spoke `t1`.
`(config)#exit`	Exit Configure mode.

CHAPTER 12 BGP-VPLS Configuration

This chapter contains configurations for Border Gateway Protocol VPLS 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.

Topology

The diagram depicts the topology for the configuration examples that follow.

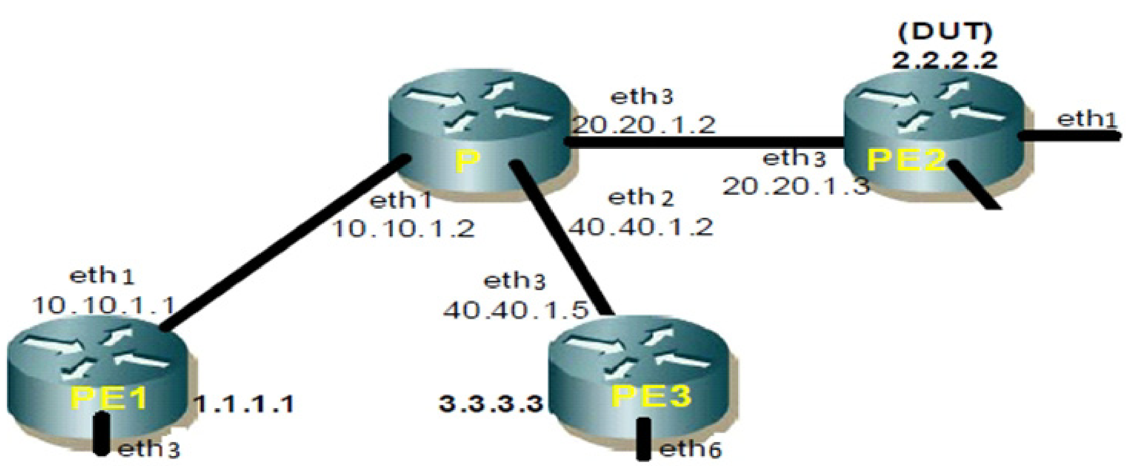


Figure 12-1: Sample Topology for BGP-VPLS Signaling

BGP-VPLS Configuration

PE-1 NSM

`#configure terminal`	Enter configuration mode.
`(config)#interface eth1`	Specify the interface `(eth1)` 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 `eth1`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Specify the loopback address.
`(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)#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)#route-target 1:100`	Route target is optional command, and if configured it should be same in all PE nodes, per VPLS instance.
`(config-vpls-sig)#rd 2:100`	Route distinguisher (rd) is an optional command.
`(config-vpls-sig)#ve-range 8`	VE range specifies ranges of VE IDs for a VPLS in one AS. It should be configured in multiple of 8 between <8-128>.
`(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)#interface eth3`	Specify the interface `(eth3)` 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`	Associate an interface with the VPLS instance for port binding by specifying the VPLS name on the interface. Repeat this step for all interfaces to be associated with this VPLS instance.
`(config-if)#exit`	Exit interface mode.

PE1 - LDP

#configure terminal	Enter configuration mode
(config)#router ldp	Enter Router LDP mode.
(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 eth1	Specify the interface (eth1) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on interface eth1.
(config-if)#exit	Exit interface mode.

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)#exit	Exit Router mode.

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.

BGP Communities

If the BGP configuration type is ZebOS-XP, the following commands are enabled by default, so there is no need to proceed. In case of standard BGP type, the following commands needs to be explicitly configured.

(config-router-af)#neighbor 2.2.2.2 send-community extended	Configure the send-community as extended.
(config-router-af)#neighbor 3.3.3.3 send-community extended	Configure the send-community as extended.
(config-router-af)#exit	Exit the address family mode.

PE2 - NSM

#configure terminal	Enter configuration mode.
(config)#interface eth3	Specify the interface (eth3) 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 eth3.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback address.
(config-if)#ip address 2.2.2.2/32	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)#route-target 1:100	Route target is an optional command. If configured it should be the same in all PE nodes, per VPLS instance.
(config-vpls-sig)#rd 2:100	Route distinguisher (rd) is an optional command.
(config-vpls-sig)#ve-range 8	VE range specifies ranges of VE IDs for a VPLS in one AS; should be in multiples of 8 in the range <8-128>.
(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)#interface eth1	Specify the interface (eth1) 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	Associate an interface with the VPLS instance for port binding by specifying the VPLS name on the interface. Repeat this step for all interfaces to be associated with this VPLS instance.
(config-if)#exit	Exit interface mode.

PE2 - LDP

`#configure terminal`	Enter configuration mode
`(config)#router ldp`	Enter Router LDP mode.
`(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 eth3`	Specify the interface `(eth3)` to be configured.
`(config-if)#enable-ldp ipv4`	Enable LDP on the specified interface (`eth3`).
`(config-if)#exit`	Exit interface mode.

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)#exit`	Exit Router mode.

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.

BGP Communities

If the BGP configuration type is ZebOS-XP, the following commands are enabled by default, so there is no need to proceed. In case of standard BGP type, the following commands needs to be explicitly configured.

(config-router-af)#neighbor 1.1.1.1 send-community extended	Configure the send-community as extended.
(config-router-af)#neighbor 3.3.3.3 send-community extended	Configure the send-community as extended.
(config-router-af)#exit	Exit the specified address family.

PE3 - NSM

#configure terminal	Enter configuration mode.
(config)#interface eth3	Specify the interface (eth3) 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 eth3.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback address.
(config-if)#ip address 3.3.3.3/32	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. Otherwise, Signaling does not take place. VE ID should be unique per VPLS instance.
(config-vpls-sig)#route-target 1:100	Route target is optional command; if configured it should be the same in all PE nodes, per VPLS instance.
(config-vpls-sig)#rd 2:100	Rd is an optional command.
(config-vpls-sig)#ve-range 8	VE range identifies ranges of VE IDs for a VPLS in one AS; should be expressed as a multiple of 8 between <8-128>.
(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)#interface eth6	Specify the interface (eth6) 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	Associate an interface with the VPLS instance for port binding by specifying the VPLS name on the interface. Repeat this step for all interfaces to be associated with this VPLS instance.
(config-if)#exit	Exit interface mode.

PE3 - LDP

#configure terminal	Enter configuration mode.
(config)#router ldp	Enter Router LDP mode.
(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 eth3	Specify the interface (eth3) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#exit	Exit interface mode.

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)#exit	Exit Router mode.

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.

BGP Communities

If the BGP configuration type is ZebOS-XP, the following commands are enabled by default, so there is no need to proceed. In case of standard BGP type, the following commands needs to be explicitly configured.

(config-router-af)#neighbor 1.1.1.1 send-community extended	Configure the send-community as extended.
(config-router-af)#neighbor 3.3.3.3 send-community extended	Configure the send-community as extended.
(config-router-af)#exit	Exit the specified address family.

P - NSM

#configure terminal	Enter configuration mode.
(config)#interface eth1	Specify the interface (eth1) 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 eth1.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Specify the interface (eth2) 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 eth2.
(config-if)#exit	Exit interface mode.
(config)#interface eth3	Specify the interface (eth3) 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 eth3.
(config-if)#exit	Exit interface mode.

P - LDP

#configure terminal	Enter configuration mode.
(config)#router ldp	Enter Router LDP mode.
(config-router)#exit	Exit Router mode.
(config)#interface eth1	Specify the interface (eth1) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Specify the interface (eth2) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface eth3	Specify the interface (eth3) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#exit	Exit interface mode.

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)#exit`	Exit Router mode.

Validation

PE1

```
#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: BGP
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1400
 Description: none
 Configured interfaces: eth3
 Mesh Peers:  2.2.2.2 (Up)
                     3.3.3.3 (Up)
#show mpls vpls v1
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: BGP
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1400
 Description: none
 Configured interfaces: eth3
 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
25         2.2.2.2           53120         18         eth1           17
2/Up      1         BGP
25         3.3.3.3           53121         19         eth1           17
2/Up      2         BGP
#show bgp l2vpn detail
VPLS ID: 25
VPLS Type: Ethernet VLAN
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:12
  Remote (LB:16,VBO:0,VBS:8)  Local (LB:16,VBO:0,VBS:8)
  LB sent on known VEID:Yes
  In Label:18, Out Label:17
  PW Status:Established
  Address:3.3.3.3, RD:2:100, VE-ID:3
  VC Details: VC-ID:13
```

```
      Remote (LB:16,VBO:0,VBS:8)  Local (LB:16,VBO:0,VBS:8)
      LB sent on known VEID:Yes
      In Label:19, Out Label:17
      PW Status:Established
    #

    #show bgp l2vpn vpls 25
    VPLS ID: 25
    VPLS Type: Ethernet VLAN
    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:12
      Remote (LB:16,VBO:0,VBS:8)  Local (LB:16,VBO:0,VBS:8)
      LB sent on known VEID:Yes
      In Label:18, Out Label:17
      PW Status:Established

      Address:3.3.3.3, RD:2:100, VE-ID:3
      VC Details: VC-ID:13
      Remote (LB:16,VBO:0,VBS:8)  Local (LB:16,VBO:0,VBS:8)
      LB sent on known VEID:Yes
      In Label:19, Out Label:17
      PW Status:Established

    #
```

PE2

```
#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: BGP
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1400
 Description: none
 Configured interfaces: eth1
 Mesh Peers:  1.1.1.1 (Up)
                       3.3.3.3 (Up)
#
#show mpls vpls v1
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: BGP
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1400
 Description: none
 Configured interfaces: eth1
 Mesh Peers:  1.1.1.1 (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
25         1.1.1.1           53123         17         eth3           18
2/Up      2         BGP
25         3.3.3.3           53121         19         eth3           18
2/Up      1         BGP
#
```



```
#show bgp l2vpn detail

VPLS ID: 25
VPLS Type: Ethernet VLAN
VE-ID: 2
Discovered Peers: 2
Route-Target: 1:100
Local RD: 2:100
 Mesh Peers:
  Address:1.1.1.1, RD:2:100, VE-ID:1
  VC Details: VC-ID:21
  Remote (LB:16,VBO:0,VBS:8)  Local (LB:16,VBO:0,VBS:8)
  LB sent on known VEID:Yes
  In Label:17, Out Label:18
  PW Status:Established

  Address:3.3.3.3, RD:2:100, VE-ID:3
  VC Details: VC-ID:23
  Remote (LB:16,VBO:0,VBS:8)  Local (LB:16,VBO:0,VBS:8)
  LB sent on known VEID:Yes
  In Label:19, Out Label:18
  PW Status:Established
#

#show bgp l2vpn vpls 25

VPLS ID: 25
VPLS Type: Ethernet VLAN
VE-ID: 2
Discovered Peers: 2
Route-Target: 1:100
Local RD: 2:100
 Mesh Peers:
  Address:1.1.1.1, RD:2:100, VE-ID:1
  VC Details: VC-ID:21
  Remote (LB:16,VBO:0,VBS:8)  Local (LB:16,VBO:0,VBS:8)
  LB sent on known VEID:Yes
  In Label:17, Out Label:18
  PW Status:Established

  Address:3.3.3.3, RD:2:100, VE-ID:3
  VC Details: VC-ID:23
  Remote (LB:16,VBO:0,VBS:8)  Local (LB:16,VBO:0,VBS:8)
  LB sent on known VEID:Yes
  In Label:19, Out Label:18
  PW Status:Established
#
```

PE3

```
#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: BGP
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1400
 Description: none
 Configured interfaces: eth6
 Mesh Peers:  1.1.1.1 (Up)
```

```
              2.2.2.2 (Up)
#
#show mpls vpls v1
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: BGP
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1400
 Description: none
 Configured interfaces: eth6
 Mesh Peers:  1.1.1.1 (Up)
              2.2.2.2 (Up)
#
#show mpls vpls mesh
VPLS-ID    Peer Addr         Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX  SIG-Protocol
25         1.1.1.1           53122         17         eth3           19
2/Up      2         BGP
25         2.2.2.2           53120         18         eth3           19
2/Up      1         BGP
#
#show bgp l2vpn detail

VPLS ID: 25
VPLS Type: Ethernet VLAN
VE-ID: 3
Discovered Peers: 2
Route-Target: 1:100
Local RD: 2:100
 Mesh Peers:
  Address:1.1.1.1, RD:2:100, VE-ID:1
  VC Details: VC-ID:31
  Remote (LB:16,VBO:0,VBS:8)  Local (LB:16,VBO:0,VBS:8)
  LB sent on known VEID:Yes
  In Label:17, Out Label:19
  PW Status:Established

  Address:2.2.2.2, RD:2:100, VE-ID:2
  VC Details: VC-ID:32
  Remote (LB:16,VBO:0,VBS:8)  Local (LB:16,VBO:0,VBS:8)
  LB sent on known VEID:Yes
  In Label:18, Out Label:19
  PW Status:Established
#

#show bgp l2vpn vpls 25

VPLS ID: 25
VPLS Type: Ethernet VLAN
VE-ID: 3
Discovered Peers: 2
Route-Target: 1:100
Local RD: 2:100
 Mesh Peers:
  Address:1.1.1.1, RD:2:100, VE-ID:1
  VC Details: VC-ID:31
  Remote (LB:16,VBO:0,VBS:8)  Local (LB:16,VBO:0,VBS:8)
  LB sent on known VEID:Yes
  In Label:17, Out Label:19
```



```
    PW Status:Established

    Address:2.2.2.2, RD:2:100, VE-ID:2
    VC Details: VC-ID:32
    Remote (LB:16,VBO:0,VBS:8)  Local (LB:16,VBO:0,VBS:8)
    LB sent on known VEID:Yes
    In Label:18, Out Label:19
    PW Status:Established
  #
```

CHAPTER 13 MPLS Layer 2 Virtual Circuit Configuration

This chapter shjows configurations for MPLS Layer 2 Virtual Circuits.

For details about the commands used, see:

- *Network Services Module Command Reference*
- *Label Distribution Protocol Command Reference*
- *Open Shortest Path First Command Reference*

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 PE1; and Host3 and Host4 are connected to PE2. The VC is established between PE1 and PE2. Interface eth1, on PE1 and PE2, is connected to the customer network; eth2, on PE1 and PE2, is connected to the MPLS cloud.

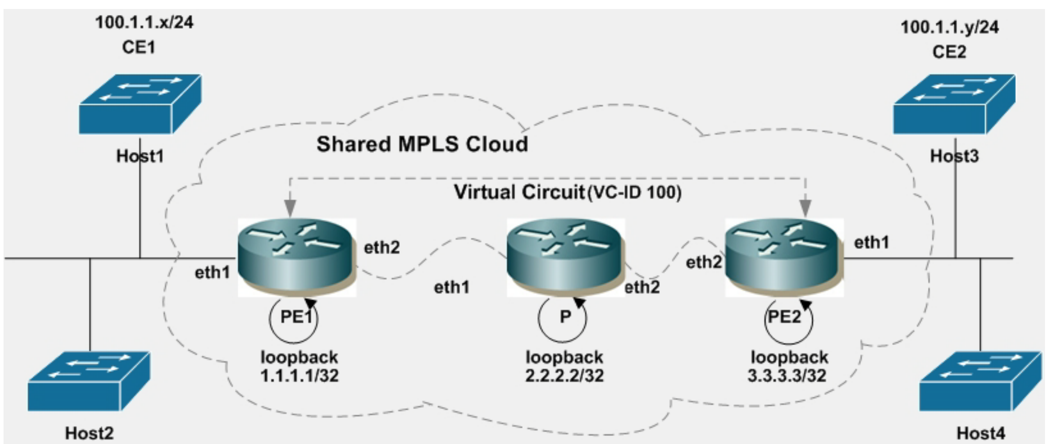


Figure 13-1: MPLS Layer 2 Virtual Circuit

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 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.
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 lo0`	Specify the loopback interface `(lo0)` 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)#exit`	Exit interface mode.
`(config)#interface eth2`	Specify the interface `(eth2)` to be configured.
`(config-if)#label-switching`	Enable label switching on interface `eth2`.
`(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.

P

`#configure terminal`	Enter configure mode.
`(config)#interface lo0`	Specify the loopback interface `(lo0)` to be configured.
`(config-if)#ip address 2.2.2.2/32`	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)#label-switching`	Enable label switching on interface `eth1`.
`(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 eth2`	Specify the interface `(eth2)` to be configured.
`(config-if)#label-switching`	Enable label switching on interface `eth2`.
`(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 10.1.1.0/24 area 0`
`(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.

PE2

`#configure terminal`	Enter configure mode.
`(config)#interface lo0`	Specify the loopback interface `(lo0)` to be configured.
`(config-if)#ip address 3.3.3.3/32`	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)#label-switching`	Enable label switching on interface `eth2`.
`(config-if)#ip address 20.1.1.3/24`	Set the IP address of the interface to `20.1.1.3/24`.
`(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 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

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)#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. In addition, use the parameter “ipv6” if you are configuring an IPv6 interface.
`(config-router)#targeted-peer ipv4 3.3.3.3`	Specify the targeted LDP peer on PE1.
`(config-router)#exit`	Exit the `Router` mode.
`(config)#interface eth2`	Specify the interface `(eth2)` to be configured.
`(config-if)#label-switching`	Enable label switching on interface `eth2`.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `eth2`.

P

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter the `Router` mode.
`(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. In addition, use the parameter “ipv6” if you are configuring an IPv6 interface.

(config-router)#exit	Exit the Router mode.
(config)#interface eth1	Specify the interface (eth1) to be configured.
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-ldp ipv4	Enable LDP on interface eth2.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Specify the interface (eth2) to be configured.
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-ldp ipv4	Enable LDP on interface eth2.

PE2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router 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. In addition, use the parameter “ipv6” if you are configuring an IPv6 interface.
(config-router)#targeted-peer ipv4 1.1.1.1	Specify the targeted LDP peer on PE2.
(config-router)#exit	Exit the Router mode.
(config)#interface eth2	Specify the interface (eth2) to be configured.
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-ldp ipv4	Enable LDP on interface eth2.

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 t1 100 3.3.3.3	Configure the VC for PE2. In this example, t1 is the VC name, 100 is the VC ID, and 3.3.3.3 is the VC endpoint IP address.

PE2

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t1 100 1.1.1.1	Configure the VC for PE1. In this example, t1 is the VC name, 100 is the VC ID, and 1.1.1.1 is the VC endpoint IP address.

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, HDLC or PPP.

Layer 2 Untagged Traffic

Use Access mode for Layer 2 untagged traffic.

PE1

`#configure terminal`	Enter configure mode.
`(config)#bridge 1 protocol ieee vlan-bridge`	Specify the VLAN for bridge `1`.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#bridge-group 1`	Associate the `eth1` interface with bridge group `1`.
`(config-if)#switchport mode access`	Set the switching characteristics of this interface to access mode.
`(config-if)#mpls-l2-circuit t1`	Bind the interface to the VC.

PE2

`#configure terminal`	Enter configure mode.
`(config)#bridge 1 protocol ieee vlan-bridge`	Specify the VLAN for bridge `1`.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#bridge-group 1`	Associate the `eth1` interface with bridge group `1`.
`(config-if)#switchport mode access`	Set the switching characteristics of this interface to Access mode.
`(config-if)#mpls-l2-circuit t1`	Bind the interface to the VC.

Layer 2 Tagged Traffic

Use Trunk mode for Layer-2 tagged traffic. The following configuration allows only VLAN 2 and 3 traffic.

PE1

`#configure terminal`	Enter configure mode.
`(config)#bridge 1 protocol ieee vlan-bridge`	Specify the VLAN for bridge `1`.
`(config)#mpls l2-circuit t2 200 3.3.3.3`	Configure the VC for PE2. In this example, `t2` is the VC name, `200` is the VC ID, and `3.3.3.3` is the VC endpoint IP address.
`(config)#vlan database`	Enter the `VLAN` configuration mode.
`(config-vlan)#vlan 2 bridge 1`	Enable the state of VLAN 2 on bridge `1`.
`(config-vlan)#vlan 3 bridge 1`	Enable the state of VLAN 3 on bridge `1`.

`(config-vlan)#exit`	Exit the `VLAN` configuration mode.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#bridge-group 1`	Associate the `eth1` interface with bridge group `1`.
`(config-if)#switchport mode trunk`	Set the switching characteristics of this interface to Trunk mode.
`(config-if)#switchport trunk allowed vlan add 2`	Enable VLAN ID 2 on this port.
`(config-if)#switchport trunk allowed vlan add 3`	Enable VLAN ID 3 on this port.
`(config-if)#mpls-l2-circuit t1 vlan 2`	Allow VLAN 2 traffic on this VC.
`(config-if)#mpls-l2-circuit t2 vlan 3`	Allow VLAN 3 traffic on this VC.

PE2

`#configure terminal`	Enter configure mode.
`(config)#bridge 1 protocol ieee vlan-bridge`	Specify the VLAN for bridge `1`.
`(config)#mpls l2-circuit t2 200 1.1.1.1`	Configure the VC for PE2. 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)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#bridge-group 1`	Associate the `eth1` interface with bridge group `1`.
`(config-if)#switchport mode trunk`	Set the switching characteristics of this interface to Trunk mode.
`(config-if)#switchport trunk allowed vlan add 2`	Enable VLAN ID 2 on this port.
`(config-if)#switchport trunk allowed vlan add 3`	Enable VLAN ID 3 on this port.
`(config-if)#mpls-l2-circuit t1 vlan 2`	Allow VLAN 2 traffic on this VC.
`(config-if)#mpls-l2-circuit t2 vlan 3`	Allow VLAN 3 traffic on this VC.

Validation

Use the show ldp mpls-l2-circuit (Control Plane) command in the LDP daemon, and the show mpls vc-table (Forwarding Plane) command in the NSM daemon, 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          eth1         UP        ethernet 52480        52480         3.3.3.3

#show mpls vc-table
VC-ID    Inner-Vlan-ID In Intf  Out Intf  Out Label  Nexthop   Status
100       N/A            eth1     eth2      52480      3.3.3.3   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
```

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 FTN entry
3. bind the VC; all steps are in the configurations that follow.

PE1

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit t1 100 3.3.3.3 manual`	Configure the VC ID with the manual option (no signalling used).
`(config)#mpls l2-circuit-ftn-entry 100 1000 2000 3.3.3.3 eth 1 eth 2`	Add an FTN entry; where `1000` is the incoming label, `2000` is the outgoing label, `3.3.3.3` is the endpoint, `eth1` is the incoming interface name, and `eth 2` is outgoing interface name.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#mpls-l2-circuit t1`	Bind the interface to the VC.

PE2

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit t1 100 1.1.1.1 manual`	Configure the VC ID with the manual option (no signalling used).
`(config)#mpls l2-circuit-ftn-entry 100 2000 1000 1.1.1.1 eth 1 eth 2`	Add an FTN entry; where `2000` is the incoming label, `1000` is the outgoing label, `1.1.1.1` is the endpoint, `eth1` is the incoming interface name, and `eth 2` is outgoing interface name.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#mpls-l2-circuit t1`	Bind the interface to the VC.

Validation

This example shows number of configured VCs and its status.

```
#show mpls vc-table count
 -------------------------------
  Num PWs       : 25000
  Active PWs    : 25000
```

```
  OAM-only PWs : 0
  Inactive PWs : 0
 -------------------------------

 #show ldp mpls-l2-circuit count
 ----------------------------------------------
 Num Signaled PWs: 25000          [UP: 25000]
 ----------------------------------------------
```

Configure VC with BGP auto discovery and LDP Signaling

Topology

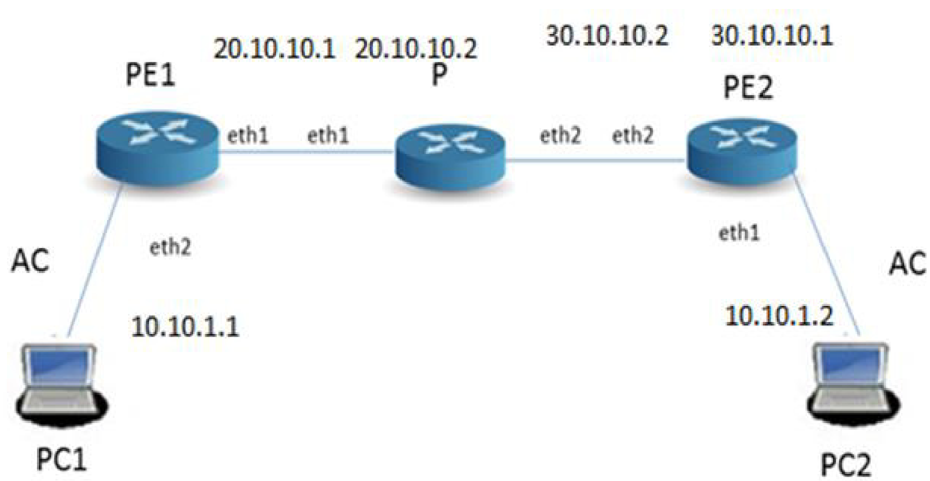


Figure 13-2: Sample Topology for BGP-VPLS Signaling

BGP-VC Configuration

PE-1 NSM

`#configure terminal`	Enter configuration mode.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#ip address 20.10.10.1/24`	Set the IP address of the interface to `20.10.10.1/24`.
`(config-if)#label-switching`	Enable label switching on interface `eth1`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Specify the loopback address.
`(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)#exit`	Exit interface mode
`(config)#l2vpn-vpws vpws1`	Create an instance of VPWS, and switch to the VPWS command mode, by specifying the VPWS name (vpws1)
`(config-vpls)# protocol ldp autodiscovery-bgp`	Enter the Signaling ldp mode for BGP AUTO-DISCOVERY VPWS.
`(config-vpls)#vc-id 30`	Configure the MTU for the VPWS. (Default is 1500; range is <576 - 65535>.
`(config-vpls-sig)# rd 1:200`	Route distinguisher (rd) is an optional command.
`(config-vpls-sig)#route-target 6:300`	Route target is optional command, and if configured it should be same in all PE nodes, per VPWS instance.
`(config-vpls-sig)#no shutdown`	Enable the VPWS instance.
`(config-vpls)#exit`	Exit VPWS mode.
`(config)#l2vpn-vpws vpws2`	Create an instance of VPWS, and switch to the VPWS
`(config-vpls)# protocol ldp autodiscovery-bgp`	Enter the Signaling ldp mode for BGP AUTO-DISCOVERY VPWS.
`(config-vpls)#vc-id 40`	Configure the MTU for the VPWS. (Default is 1500; range is
`(config-vpls-sig)# rd 1:300`	Route distinguisher (rd) is an optional command.
`(config-vpls-sig)#route-target 6:200`	Route target is optional command, and if configured it
`(config-vpls-sig)#no shutdown`	Enable the VPWS instance.
`(config-vpls)#exit`	Exit VPWS mode.

Bind Customer Interface to VC PE 1

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)

Layer 2 Un-tagged Traffic

`#configure terminal`	Enter configuration mode.
`(config)#bridge 1 protocol iee vlan-bridge`	Creation of bridge 1.
`(config)#vlan database`	Vlan database.
`(config-vlan)#vlan 2 bridge 1`	Enable VLAN 2
`(config-vlan)#vlan 3 bridge 1`	Enable VLAN 3
`(config-vlan)#end`	Exit Configuration mode.
`(config)#interface eth3`	Specify the interface `(eth3)` to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode. (VPWS can be bound only on the
`(config-if)#bridge-group 1`	Specify the interface as a part of Bridge1
`(config-if)#switchport mode trunk`	Interface as a trunk port
`(config-if)#switchport trunk allowed vlan all`	
`(config-if)#l2vpn-vpws vpws1 vlan 2`	Associate an vlan interface with the VPWS instance for port binding by specifying the VPWS name on the interface. Repeat this step for all interfaces to be associated with this VPWS instance.
`(config-vpls)#exit`	Exit interface mode.

Layer 2 Un-tagged Traffic

Use Access mode for Layer 2 untagged traffic.

`(config)#interface eth4`	Specify the interface `(eth4)` to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode. (VPWS can be bound only on the Layer-2 port.)
`(config-if)#l2vpn-vpws vpws2`	Associate an interface with the VPWS instance for port binding by specifying the VPWS name on the interface. Repeat this step for all interfaces to be associated with this VPWS instance.
`(config-if)#exit`	Exit interface mode.

PE1 - LDP

`#configure terminal`	Enter configuration mode
`(config)#router ldp`	Enter Router LDP mode.
`(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)# targeted-peer ipv4 3.3.3.3`	Configure the targeted peer1 for PE1.
`(config-router)#exit`	Exit Router mode.
`(config)#interface eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `eth1`.
`(config-if)#exit`	Exit interface mode.

PE1 - OSPF

`#configure terminal`	Enter configure mode.
`(config)#router ospf 1`	Configure the OSPF routing process, and specify the process ID.
`(config-router)#network 20.10.10.0/24 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)#exit`	Exit Router mode.

PE1 - BGP

`#configure terminal`	Enter configuration mode.
`(config)#router bgp 100`	Enter BGP Configure mode.
`(config-router)#neighbor 3.3.3.3 remote-as 100`	Configure PE2 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 l2vpn vpls`	Configure address-family l2vpn vpls.
`(config-router-af)#neighbor 3.3.3.3 activate`	Activate PE2 in the VPLS address family.
`(config-router-af)#exit`	Exit the address family mode.

PE1 - NSM

`#configure terminal`	Enter configuration mode.
`(config)#interface eth2`	Specify the interface `(eth2)` to be configured.
`(config-if)#ip address 30.10.10.1/24`	Set the IP address of the interface to `30.10.10.1/24`.

(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback address.
(config-if)#ip address 3.3.3.3/32	Set the IP address of the loopback interface to 3.3.3.3/32.
(config-if)#exit	Exit interface mode
(config)#l2vpn-vpws vpws1	Create an instance of VPWS, and switch to the VPWS command mode, by specifying the VPWS name (vpws1)
(config-vpls)# protocol ldp autodiscovery-bgp	Enter the Signaling ldp mode for BGP AUTO-DISCOVERY VPWS.
(config-vpls)#vc-id 30	Configure the MTU for the VPWS. (Default is 1500; range is <576 - 65535>.
(config-vpls-sig)# rd 1:200	Route distinguisher (rd) is an optional command.
(config-vpls-sig)#route-target 6:300	Route target is optional command, and if configured it should be same in all PE nodes, per VPWS instance.
(config-vpls-sig)#no shutdown	Enable the VPWS instance.
(config-vpls)#exit	Exit VPWS mode.
(config)#l2vpn-vpws vpws2	Create an instance of VPWS, and switch to the VPWS
(config-vpls)# protocol ldp autodiscovery-bgp	Enter the Signaling ldp mode for BGP AUTO-DISCOVERY VPWS.
(config-vpls)#vc-id 40	Configure the MTU for the VPWS. (Default is 1500; range is
(config-vpls-sig)# rd 1:300	Route distinguisher (rd) is an optional command.
(config-vpls-sig)#route-target 6:200	Route target is optional command, and if configured it
(config-vpls-sig)#no shutdown	Enable the VPWS instance.
(config-vpls)#exit	Exit VPWS mode.

Bind Customer Interface to VC For PE 2

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)

Layer-2 Tagged Traffic

#configure terminal	Enter configuration mode.
(config)#bridge 1 protocol iee vlan-bridge	Creation of bridge 1.
(config)#vlan database	Vlan database.
(config-vlan)#vlan 2 bridge 1	Enable VLAN 2
(config-vlan)#vlan 3 bridge 1	Enable VLAN 3

`(config-vlan)#end`	Exit Configuration mode.
`(config)#interface eth3`	Specify the interface `(eth3)` to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode. (VPWS can be bound only on the
`(config-if)#bridge-group 1`	Specify the interface as a part of Bridge1
`(config-if)#switchport mode trunk`	Interface as a trunk port
`(config-if)#switchport trunk allowed vlan all`	
`(config-if)#l2vpn-vpws vpws1 vlan 2`	Associate an vlan interface with the VPWS instance for port binding by specifying the VPWS name on the interface. Repeat this step for all interfaces to be associated with this VPWS instance.
`(config-vpls)#exit`	Exit interface mode.

Layer 2 Un-tagged Traffic

Use Access mode for Layer 2 untagged traffic.

`(config)#interface eth4`	Specify the interface `(eth4)` to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode. (VPWS can be bound only on the Layer-2 port.)
`(config-if)#l2vpn-vpws vpws2`	Associate an interface with the VPWS instance for port binding by specifying the VPWS name on the interface. Repeat this step for all interfaces to be associated with this VPWS instance.
`(config-if)#exit`	Exit interface mode.

PE2 - LDP

`#configure terminal`	Enter configuration mode
`(config)#router ldp`	Enter Router LDP mode.
`(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)# targeted-peer ipv4 1.1.1.1`	Configure the targeted peer1 for PE2.
`(config-router)#exit`	Exit Router mode.
`(config)#interface eth2`	Specify the interface (eth2) to be configured.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface eth2.
`(config-if)#exit`	Exit interface mode.

PE2 - OSPF

#configure terminal	Enter configuration mode.
(config)#router ospf 1	Configure the OSPF routing process, and specify the process ID.
(config-router)#network 30.10.10.0/24 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)#exit	Exit Router mode.

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)#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	Exit the specified address family.

P - NSM

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback address.
(config-if)#ip address 2.2.2.2/32	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 20.10.10.2/24	Set the IP address of the interface to `20.10.10.2/24`.
(config-if)#label-switching	Enable label switching on interface `eth1`.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Specify the interface `(eth2)` to be configured.
(config-if)#ip address 30.10.10.2/24	Set the IP address of the interface to `30.10.10.2/24`.
(config-if)#label-switching	Enable label switching on interface `eth2`.
(config-if)#exit	Exit interface mode.

P - LDP

#configure terminal	Enter configuration mode.
(config)#router ldp	Enter Router LDP mode.

`(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 eth1`	Specify the interface `(eth1)` to be configured.
`(config-if)#enable-ldp ipv4`	Enable LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Specify the interface `(eth2)` to be configured.
`(config-if)#enable-ldp ipv4`	Enable LDP on the interface.
`(config-if)#exit`	Exit interface mode.

P - OSPF

`#configure terminal`	Enter configuration mode.
`(config)#router ospf 1`	Configure the OSPF routing process, and specify the process ID.
`(config-router)#network 20.10.10.0/24 area 0`	Define the interfaces on which OSPF runs, and specify the backbone area 0.
`(config-router)#network 30.10.10.0/24 area 0`	
`(config-router)#network 2.2.2.2/32 area 0`	
`(config-router)#exit`	Exit Router mode.

Validation for PE1

```
#show ldp mpls-l2-circuit
Transport Client     VC     VC            Local       Remote      Destination
VC ID     Binding    State  Type          VC Label    VC Label    Address
N/A       eth4       UP     Ethernet VLAN 22          646         3.3.3.3
N/A       eth5       UP     Ethernet      23          647         3.3.3.3
#sho mpls vc-table
VC-ID       Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label  Nexthop
Status
30           2       eth4          eth1          646        642           3.3.3.3
Active
40           N/A     eth5          eth1          647        642           3.3.3.3
Active
#sho bgp l2vpn peers
VPLS-ID   VPLS-TYPE     Discovered-Peers  RD       Route-Target
30        Ethernet VLAN     1             1:200          6:300
500       Ethernet          2             2:300          1:100
40        Ethernet          1             1:300          6:200
#
```

Validation for PE2

```
#sho ldp mpls-l2-circuit
Transport Client     VC     VC            Local       Remote      Destination
VC ID     Binding    State  Type          VC Label    VC Label    Address
```

```
N/A       eth4       UP     Ethernet VLAN 646         22          1.1.1.1
N/A       eth5       UP     Ethernet      647         23          1.1.1.1
#sho mpls vc-table
VC-ID      Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label  Nexthop
Status
30          2        eth4          eth2          22         640           1.1.1.1
Active
40          N/A      eth5          eth2          23         640           1.1.1.1
Active
#sho mpls vc-table ?
#sho bgp l2vpn peers
VPLS-ID   VPLS-TYPE     Discovered-Peers  RD       Route-Target
30        Ethernet VLAN     1             1:200         6:300
500       Ethernet          2             2:300         1:100
40        Ethernet          1             1:300         6:200
```

CHAPTER 14 DiffServ-TE Configuration

This chapter contains a step-by-step configuration for DiffServ-TE.

See the *Network Services Module Command Reference* and the *Resource Reservation Protocol - Traffic Engineering Command Reference* for details about the commands used.

Topology

In this example, DiffServ-TE is configured to set up trunks for various classes of traffic.

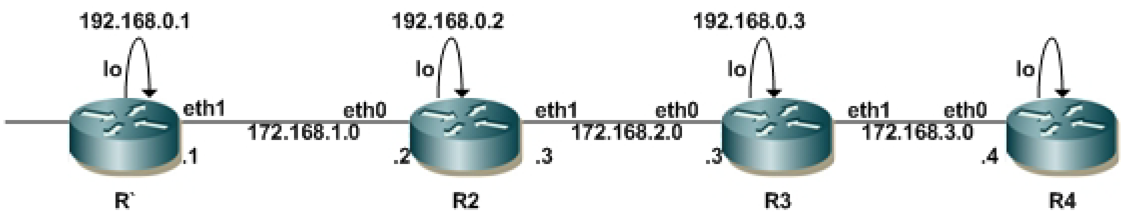


Figure 14-1: DiffServ TE Topology

R1

Step 1: Define Class-type Name

Define class-type names, and enable class types. Four class types (default, voice-high, voice-low and data) are defined.

R1-NSM

```
mpls class-type ct0 default
mpls class-type ct1 voice-high
mpls class-type ct2 voice-low
mpls class-type ct3 data
```

Step 2: Configure TE Class

Configure the TE Class defining the class-type name and pre-emption priority for each TE class. Assign the `voice-high` class-type the highest priority (numerically lowest), and assign the `default` class-type the lowest priority (numerically highest).

R1-NSM

```
mpls te-class te0 default 6
mpls te-class te1 voice-high 2
mpls te-class te2 voice-low 4
mpls te-class te3 data 5
```

Step 3: Configure Bandwidth Constraint

Enable label switching on interface,`eth1`, set the corresponding IP address on the interface, reserve the bandwidth, and configure the bandwidth constraint for each class type on the `eth1` interface.

Bandwidth constraints are defined so that 100 MB of reservable bandwidth is divided among the defined class types. These priority assignments guarantee that `data`, `voice-low`, and `default` LSPs cannot pre-empt a `voice-high` LSP. Similarly, `default` and `data` cannot pre-empt `voice-low`. However, `voice-high` and `voice-low` can pre-empt both `data` and `default` LSPs.

R1-NSM

```
interface eth1
   label-switching
   ip-address 172.168.1.1/24
   bandwidth 100m
   reservable-bandwidth 100m
   bandwidth-constraint voice-high 50m
   bandwidth-constraint voice-low 20m
   bandwidth-constraint data 20m
   bandwidth-constraint default 10m
   enable-rsvp
```

Step 4: Configure Class-type for Each LSP

Set up RSVP trunks

1. Create a new RSVP trunk.
2. Configure a class-type for the LSP.
3. Reserve the bandwidth in bits per second for the trunk.
4. Configure a setup priority value for this trunk.
5. Configure a hold-priority value for this trunk.
6. Specify the IPv4 egress for the LSP.

Note: Make sure that the class type name and priority values match the ones defined earlier.

R1-RSVP-TE

```
rsvp-trunk voice-trunk-1
primary no-cspf
primary class-type voice-high
primary bandwidth 10m
primary setup-priority 2
primary hold-priority 2
to 192.168.0.4
!

rsvp-trunk voice-low-1
primary no-cspf
primary class-type voice-low
```



```
primary bandwidth 5m
primary setup-priority 4
primary hold-priority 4
to 192.168.0.4
!
rsvp-trunk data-1
primary no-cspf
primary class-type data
primary bandwidth 14m
primary setup-priority 5
primary hold-priority 5
to 192.168.0.3
```

Step 5: Enable OSPF Routing

Configure an OSPF routing process, and enable OSPF on all networks of the LSR in the MPLS cloud.

R1-OSPF

```
router ospf 100
   network 172.168.1.0/24 area 0
   network 192.168.0.1/32 area 0
```

R2

Follow Steps 1, 2, and 3 the same as for Router R1, above. Be sure to specify the relevant IP addresses for all interfaces (for example, `eth0, eth1`).

R2-NSM

```
label-switching
   ip-address 172.168.1.2/24
```

Skip Step 4, and complete Step 5.

R2-OSPF

```
router ospf 100
   network 172.168.1.0/24 area 0
   network 172.168.2.0/24 area 0
   network 192.168.0.2/32 area 0
```

R3

Follow Steps 1, 2, and 3 the same as for Router R1, above. Be sure to specify the relevant IP addresses for all interfaces (for example, `eth0, eth1`).

R3-NSM

```
label-switching
   ip-address 172.168.2.3/24
```

Skip Step 4, and complete Step 5.

R3-OSPF

```
router ospf 100
   network 172.168.2.0/24 area 0
   network 172.168.3.0/24 area 0
   network 192.168.0.3/32 area 0
```

R4

Follow Steps 1, 2, and 3, the same as for Router R1, above. Make sure to specify the relevant IP addresses for all interfaces (for example, `eth0, eth1`).

R4-NSM

```
label-switching
   ip-address 172.168.3.4/24
```

Skip Step 4, and complete Step 5.

R4-OSPF

```
router ospf 100
   network 172.168.3.0/24 area 0
   network 192.168.0.4/32 area 0
```

Validation

Use the following commands to display information about the DiffServ-TE configuration:

- `show rsvp session`
- `show mpls dste class-type`
- `show mpls dste te-class`
- `show interface`

CHAPTER 15 Pseudowire Status

This chapter includes Pseudowire (PW) Status configuration examples. This feature specifies a mechanism to signal Pseudowire (PW) status messages using a PW associated channel (ACh), which is suitable for static PWs where no PW dynamic control plane exits. You can also use this feature when a Terminating Provider Edge (T-PE) needs to send a PW status message directly to a far-end T-PE. This feature allows PW Operations, Administration, and Maintenance (OAM) message mapping and PW redundancy to operate on a static PW.

This configuration section includes information on the configuration of PW status for statically configured end-to-end MPLS PWs and MPLS-TP PWs.

Terminology

`ACh`	Associated Channel
`ACH`	Associated Channel Header
`FEC`	Forwarding Equivalence Class
`LSP`	Label Switching Path
`PE`	Provider Edge
`PW`	Pseudowire
`SS-PW`	Single-Segment Pseudowire
`MS-PW`	Multi-Segment Pseudowire
`S-PE`	Switching Provider Edge Node of MS-PW
`T-PE`	Terminating Provider Edge Node of MS-PW
`OAM`	Operations Administration and Maintenance
`MPLS-TP`	MPLS Transport Profile

Topology

The following topology shows a basic PW topology.

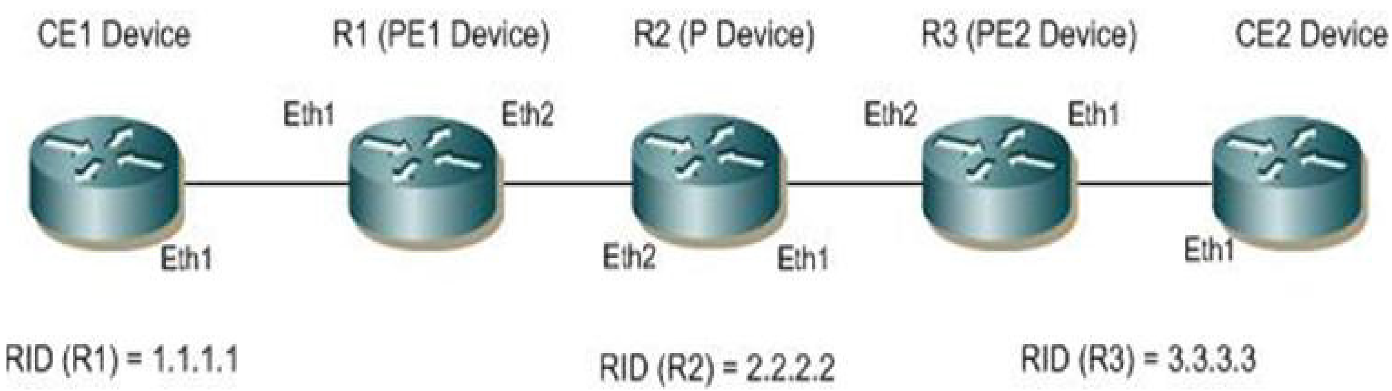


Figure 15-1: PW Topology

PW Status Commands

PW status commands and other related configurations for statically configured MPLS PWs.

```
mpls l2-circuit NAME VC-ID PEER-IP control-word tunnel-id TUNNEL-ID(manual(pw-status(REFRESH-TIME))
```

Parameter	Description
pw-status	Enables PW status for manual configured PW (Static PW). To disable it, omit this and reconfigure PW.
REFRESH-TIME	Time in seconds after which a PW status is transmitted periodically if an AC fault has occurred. The range is <0-65535>. Default is 600 seconds.

PE1

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit VC1 1 3.3.3.3 control-word tunnel-id 1 manual pw-status 5`	Configure a static VC with name VC1 with “pw-status” keyword and Refresh Timer value of 5 seconds
`(config)#bridge 1 protocol ieee vlan-bridge`	Configure bridge protocol with bridge group as 1
`(config)#interface eth1`	Enter interface mode.
`(config-if)#switchport`	Configure switchport and switch to Layer2 mode
`(config-if)#bridge-group 1`	Enable the bridge group 1
`(config-if)#switchport mode access`	Configure switchport mode as access
`(config-if)#mpls-l2-circuit VC1 ethernet`	Attach the PW1 to the interface eth1
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 1.1.1.1/32`	Set the IP address for the interface
`(config-if)#exit`	Exit interface mode
`(config)#interface eth2`	Enter interface mode.
`(config-if)#ip address 10.1.1.1/24`	Set the IP address for the interface
`(config-if)#label-switching`	Enable label switching on interface eth2
`(config-if)#exit`	Exit interface mode
`(config)#mpls l2-circuit-fib-entry 1 100 1000 3.3.3.3 eth2 eth1`	Configure a FIB Entry for the PW1
`(config)#mpls ftn-entry tunnel-id 1 3.3.3.3/32 200 10.1.1.2 eth2 primary`	Configure a FTN Entry for forward MPLS Tunnel
`(config)#mpls ilm-entry 2222 eth2 pop`	Configure a ILM POP Entry for reverse MPLS Tunnel

P

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 2.2.2.2/32`	Set the IP address for the interface

`(config-if)#label-switching`	Enable label switching on interface lo
`(config-if)#exit`	Exit interface mode
`(config)#interface eth1`	Enter interface mode.
`(config-if)#ip address 20.1.1.1/24`	Set the IP address for the interface
`(config-if)#label-switching`	Enable label switching on interface eth1
`(config-if)#exit`	Exit interface mode
`(config)#interface eth2`	Enter interface mode.
`(config-if)#ip address 10.1.1.2/24`	Set the IP address for the interface
`(config-if)#label-switching`	Enable label switching on interface eth2
`(config-if)#exit`	Exit interface mode
`(config)#mpls ilm-entry 200 eth2 swap 2000 eth1 20.1.1.2 3.3.3.3/32`	Configure ILM Swap Entry for forward MPLS Tunnel
`(config)#mpls ilm-entry 111 eth1 swap 2222 eth2 10.1.1.1 1.1.1.1/32`	Configure ILM Swap Entry for reverse MPLS Tunnel

PE2

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit VC1 1 1.1.1.1 control-word tunnel-id 2 manual pw-status 10`	Configure a static VC with name VC1 with "pw-status" keyword and Refresh Timer value of 10 seconds
`(config)#bridge 1 protocol ieee vlan-bridge`	Configure bridge protocol with bridge group as 1
`(config)#interface eth1`	Enter interface mode.
`(config-if)#switchport`	Configure switchport and switch to Layer2 mode
`(config-if)#bridge-group 1`	Enable the bridge group 1
`(config-if)#switchport mode access`	Configure switchport mode as access
`(config-if)#mpls-l2-circuit VC1 ethernet`	Attach the PW1 to the interface eth1
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 3.3.3.3/32`	Set the IP address for the interface
`(config-if)#exit`	Exit interface mode
`(config)#interface eth2`	Enter interface mode.
`(config-if)#ip address 20.1.1.2/24`	Set the IP address for the interface
`(config-if)#label-switching`	Enable label switching on interface eth2
`(config-if)#exit`	Exit interface mode
`(config)#mpls l2-circuit-fib-entry 1 1000 100 1.1.1.1 eth2 eth1`	Configure a FIB Entry for the PW1
`(config)#mpls ftn-entry tunnel-id 2 1.1.1.1/32 111 20.1.1.1 eth2 primary`	Configure a FTN Entry for forward MPLS Tunnel
`(config)#mpls ilm-entry 2000 eth2 pop`	Configure a ILM POP Entry for reverse MPLS Tunnel

Validation

show mpls l2-circuit and show mpls vc-table

PW Status Commands

PW status commands and other related configurations for statically configured MPLS-TP PWs.

```
mpls l2-circuit NAME VC-ID PEER-GLOBAL-ID PEER-NODE-ID PEER-AC-ID GROUP-NAME
(manual (pw-status (REFRESH-TIME))
```

Parameter	Description
pw-status	Enables PW status for manual configured PW (Static PW). To disable it, just omit this and reconfigure PW.
REFRESH-TIME	Specifies the time in seconds after which a PW status will be transmitted periodically if an AC fault has occurred. The range is <0-65535>. Default is 600 seconds.

R1

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 999 node-id 1.1.1.1`	Configure MPLS-TP Global ID
`(config)#mpls ac-group grp1 2`	Configure MPLS-TP Access Group
`(config)#mpls l2-circuit VC1 1 888 3.3.3.3 456 grp1 manual pw-status 5`	Configure a static VC with name VC1 with "pw-status" keyword and Refresh Timer value of 5 seconds
`(config)#bridge 1 protocol ieee vlan-bridge`	Configure bridge protocol with bridge group as 1
`(config)#interface eth1`	Enter interface mode.
`(config-if)#switchport`	Configure switchport and switch to Layer2 mode
`(config-if)#bridge-group 1`	Enable the bridge group 1
`(config-if)#switchport mode access`	Configure switchport mode as access
`(config-if)# mpls-tp service-interface type layer-2 123`	Configure MPLS-TP service interface type
`(config-if)#mpls-l2-circuit VC1 ethernet`	Attach the PW1 to the interface eth1
`(config)#interface eth2`	Enter interface mode.
`(config-if)# mpls-tp provider-interface 11.11.11.11`	Set the interface eth2 as provider interface with local interface id as 11.11.11.11
`(config-if)#exit`	Exit interface mode
`(config)#mpls l2-circuit-fib-entry 1 555 666 tp-tunnel T1 eth1`	Configure a FIB Entry for the PW1
`(config)#mpls-tp tunnel 1 source 999 1.1.1.1 destination 888 3.3.3.3`	Configure a FTN Entry for MPLS Tunnel
`(config-tnl)# tunnel-name T1`	Configure Tunnel Name
`(config-tnl)# tunnel-mode bidirectional`	Configure Tunnel Mode as Bidirectional

`(config-bidir-tnl)#forward-path nhlfe-entry 1000 eth2`	Configure Forward Path nhlfe entry
`(config-bidir-tnl)# reverse-path ilm-entry 2000 eth2 pop`	Configure Reverse Path ilm pop entry

P

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 777 node-id 2.2.2.2`	Configure MPLS-TP Global ID
`(config)#interface eth1`	Enter interface mode.
`(config-if)# mpls-tp provider-interface 22.22.22.22`	Set the interface eth1 as provider interface with local interface id as 22.22.22.22
`(config-if)#exit`	Exit interface mode
`(config)#interface eth2`	Enter interface mode.
`(config-if)# mpls-tp provider-interface 33.33.33.33`	Set the interface eth2 as provider interface with local interface id as 33.33.33.33
`(config-if)#exit`	Exit interface mode
`(config)#mpls l2-circuit-fib-entry 1 555 666 tp-tunnel T1 eth1`	Configure a FIB Entry for the PW1
`(config)#mpls-tp tunnel 1 source 999 1.1.1.1 destination 888 3.3.3.3`	Configure a FTN Entry for MPLS Tunnel
`(config-tnl)# tunnel-name T1`	Configure Tunnel Name
`(config-tnl)# tunnel-mode bidirectional`	Configure Tunnel Mode as Bidirectional
`(config-bidir-tnl)# forward-path ilm-entry 1000 eth2 swap 1500 eth1`	Configure Forward Path nhlfe entry
`(config-bidir-tnl)# reverse-path ilm-entry 1500 eth1 swap 2000 eth2`	Configure Reverse Path ilm pop entry

PE2

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 888 node-id 3.3.3.3`	Configure MPLS-TP Global ID
`(config)#mpls ac-group grp1 2`	Configure MPLS-TP Access Group
`(config)#mpls l2-circuit VC1 1 999 1.1.1.1 123 grp1 manual pw-status 10`	Configure a static VC with name VC1 with “pw-status” keyword and Refresh Timer value of 5 seconds
`(config)#bridge 1 protocol ieee vlan-bridge`	Configure bridge protocol with bridge group as 1
`(config)#interface eth1`	Enter interface mode.
`(config-if)#switchport`	Configure switchport and switch to Layer2 mode
`(config-if)#bridge-group 1`	Enable the bridge group 1
`(config-if)#switchport mode access`	Configure switchport mode as access

`(config-if)# mpls-tp service-interface type layer-2 456`	Configure MPLS-TP service interface type
`(config-if)#mpls-l2-circuit VC1 ethernet`	Attach the PW1 to the interface eth1
`(config)#interface eth2`	Enter interface mode.
`(config-if)# mpls-tp provider-interface 44.44.44.44`	Set the interface eth2 as provider interface with local interface id as 11.11.11.11
`(config-if)#exit`	Exit interface mode
`(config)#mpls l2-circuit-fib-entry 1 666 555 tp-tunnel T1 eth`	Configure a FIB Entry for the PW1
`(config)#mpls-tp tunnel 1 source 999 1.1.1.1 destination 888 3.3.3.3`	Configure a FTN Entry for MPLS Tunnel
`(config-tnl)# tunnel-name T1`	Configure Tunnel Name
`(config-tnl)# tunnel-mode bidirectional`	Configure Tunnel Mode as Bidirectional
`(config-bidir-tnl)#fforward-path ilm-entry 1500 eth2 pop`	Configure Forward Path nhlfe entry
`(config-bidir-tnl)# reverse-path nhlfe-entry 1500 eth2`	Configure Reverse Path ilm pop entry

Validation

The command “show mpls l2-circuit” includes the PW status related information for Static PW.

```
#show mpls l2-circuit vc1
MPLS Layer-2 Virtual Circuit: test, id: 100 PW-INDEX: 1
Endpoint: 3.4.5.6
Control Word: 1
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: eth1
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit runtime mode is active
STATIC-PW-STATUS: Enabled,
  Local Refresh timer: 30 sec
  Local PW Status:
    Ingress AC Receive Fault
    Egress AC Transmit Fault
  Remote Refresh timer: 40 sec
  Remote PW Status:
    No faults detected
```


CHAPTER 16 PW Redundancy Configuration

This chapter contains configurations for Pseudowire Redundancy. It also provides an overview of Pseudowire concepts.

Overview

In a single-segment pseudowire (SS-PW) application, the PSN (packet switched network) layer usually provides protection for the PW. One way is by using an RSVP LSP with FRR (Fast Reroute) backup; another way is an end-to-end backup LSP (Label Switched Path). However, there are some applications where the backup PW terminates on a different target PE node, so PSN protection methods cannot protect against failure of either the target PE (provider edge) node or a remote Access Circuit (AC). It is also important to an operator that a particular PW is preferred, for example, the one with the least latency.

PW redundancy supports Label Distribution Protocol (LDP) PW and manual switchover between primary PW and secondary PW in MTU-s. In the case of PW applications, the PSN layer can provide the protection for PW. Occasionally, a TE (traffic-engineered) LSP signaled by RSVP-TE can be used as a PSN tunnel for a PW. In this scenario, TE can provide FRR to protect the end-to-end LSP in the PSN layer.

FRR-based protection schemes cannot protect against failure of PE nodes and access circuits. However, PW redundancy can protect against these failures. Multi-homed CE (customer edge) devices can be connect between two PE nodes through two access circuits to provide protection. In case of Hierarchical VPLS (HVPLS), the MTU-s can create spoke circuits at the PEs. Any one can be used to protect another.

Topology

The diagram depicts two multi-homed CE devices, CE1 and CE2, connected to two PE devices each, PE1 and PE3, and PE2 and PE4, respectively. In this scenario, multiple single-segment Ethernet pseudowires need to be signaled: PW1 between PE1 and PE2; PW2 between PE1 and PE4; PW3 between PE2 and PE3; and PW4 between PE3 and PE4.

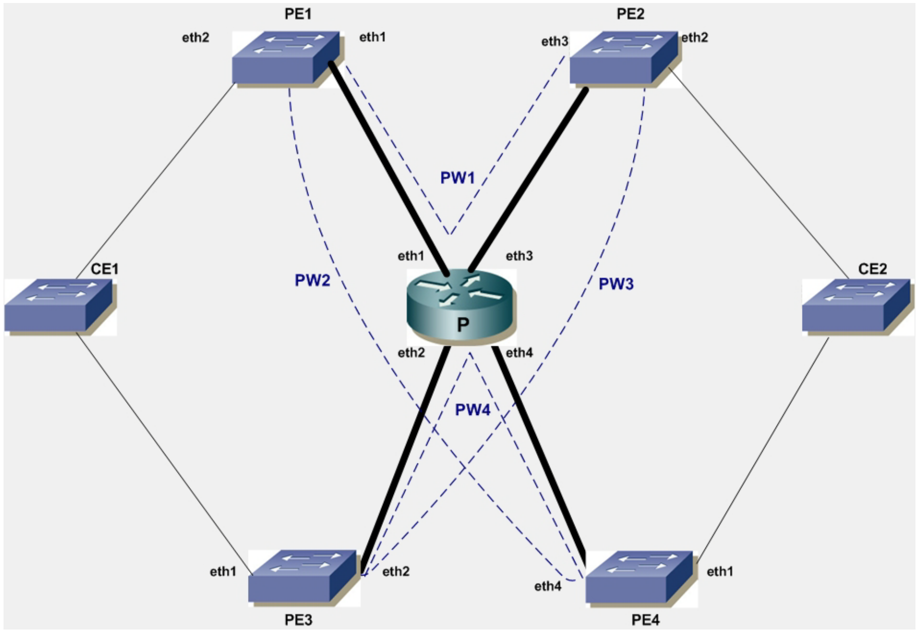


Figure 16-1: Dual-Homed CE Devices for Ethernet Pseudowires

PE1

`#configure terminal`	Enter configure mode.
`(config-if)#interface lo`	Identify the loopback interface to configure `(lo)`.
`(config-if)#ip address 66.66.66.66/32`	Set the IP address of the loopback interface to `66.66.66.66/32`.
`(config-if)#exit`	Exit interface mode
`(config)#interface eth1`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#ip address 11.0.0.66/24`	Set the IP address of the interface to `11.0.0.66/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf`	Enter the `Router OSPF` mode.
`(config-router)#network 11.0.0.0/24 area 0` `(config-router)#network 66.66.66.66/32 area 0`	Define the Network on which OSPF runs and associate the area ID (`area 0`) with the interface.
`(config-router)#exit`	Exit `Router` mode and return to `Configure` mode.
`(config)#router ldp`	Enter the `Router` mode for LDP.
`(config-router)#transport-address ipv4 66.66.66.66`	Configure loopback address as LDP transport address.
`(config-router)#pw-status-tlv`	Enable the PW Status TLV (`pw-status-tlv`).
`(config-router)#targeted-peer-ipv4 68.68.68.68`	Configure LDP targeted peer to PE2.
`(config-router)#targeted-peer-ipv4 69.69.69.69`	Configure LDP targeted peer to PE4.
`(config-router)#exit`	Exit `Router` mode and return to `Configure` mode.

`(config)#interface eth1`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable IPv4 LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls l2-circuit vc1 10 68.68.68.68`	Configure a Virtual Circuit for PE1. In this example, `vc1` is the VC name, `10` is the VC ID, and `68.68.68.68` is the endpoint IP address.
`(config)#mpls l2-circuit vc2 20 69.69.69.69`	Configure another Virtual Circuit for PE1. In this example, `vc2` is the VC name, `20` is the VC ID, and `69.69.69.69` is the endpoint IP address.
`(config-if)#interface eth2`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer 2 mode.
`(config-if)#mpls-l2-circuit vc1 ethernet`	Bind VC1 as an Ethernet circuit.
`(config-if)#mpls-l2-circuit vc2 ethernet`	Bind VC2 as an Ethernet circuit.
`(config-if)#exit`	Exit interface mode.

PE2

`#configure terminal`	Enter configure mode.
`(config-if)#interface lo`	Identify the loopback interface to configure (`lo`).
`(config-if)#ip address 68.68.68.68/24`	Set the IP address of the loopback interface to `68.68.68.68/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#label switching`	Enable label switching on the interface.
`(config-if)#ip address 33.0.0.68/24`	Set the IP address of the interface to `33.0.0.68/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf`	Enter the `Router` mode for OSPF.
`(config-router)#network 68.68.68.68/32 area 0` `(config-router)#network 33.0.0.0/24 area 0`	Define the Network on which OSPF runs and associate the area ID (`area 0`) with the interface.
`(config-router)#exit`	Exit `Router` mode and return to `Configure` mode.
`(config)#router ldp`	Enter the `Router` mode for LDP.
`(config-router)#transport-address ipv4 68.68.68.68`	Configure loopback address as LDP transport address.
`(config-router)#pw-status-tlv`	Enable the PW Status TLV (`pw-status-tlv`).
`(config-router)#targeted-peer-ipv4 66.66.66.66`	Configure LDP targeted peer to PE1.
`(config-router)#targeted-peer-ipv4 67.67.67.67`	Configure LDP targeted peer to PE3.
`(config-router)#exit`	Exit `Router` mode and return to `Configure` mode.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable IPv4 LDP on the interface.
`(config-if)#exit`	Exit interface mode.

(config)#mpls l2-circuit vc1 10 66.66.66.66	Configure a Virtual Circuit for PE2. In this example, vc1 is the VC name, 10 is the VC ID, and 66.66.66.66 is the endpoint IP address.
(config)#mpls l2-circuit vc2 20 67.67.67.67	Configure another Virtual Circuit for PE2. In this example, vc2 is the VC name, 20 is the VC ID, and 67.67.67.67 is the endpoint IP address.
(config-if)#interface eth2	Enter interface mode.
(config-if)#switchport	Switch to Layer 2 mode.
(config-if)#mpls-l2-circuit vc1 ethernet	Bind VC1 as an Ethernet circuit.
(config-if)#mpls-l2-circuit vc2 ethernet	Bind VC2 as an Ethernet circuit.
(config-if)#exit	Exit interface mode.

PE3

#configure terminal	Enter configure mode.
(config-if)#interface lo	Identify the loopback interface to configure (lo).
(config-if)#ip address 67.67.67.67/32	Set the IP address of the loopback interface to 67.67.67.67/32.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#ip address 22.0.0.67/24	Set the IP address of the interface to 22.0.0.67/24.
(config-if)#exit	Exit interface mode.
(config)#router ospf	Enter the Router mode for OSPF.
(config-router)#network 67.67.67.67/32 area 0 (config-router)#network 22.0.0.0/24 area 0	Define the Network on which OSPF runs and associate the area ID (area 0) with the interface.
(config-router)#exit	Exit Router mode and return to Configure mode.
(config)#router ldp	Enter the Router mode for LDP.
(config-router)#transport-address ipv4 67.67.67.67	Configure loopback address as LDP transport address.
(config-router)#pw-status-tlv	Enable the PW Status TLV (pw-status-tlv).
(config-router)#targeted-peer-ipv4 68.68.68.68	Configure LDP targeted peer for PE2.
(config-router)#targeted-peer-ipv4 69.69.69.69	Configure LDP targeted peer for PE4.
(config-router)#exit	Exit Router mode and return to Configure mode.
(config)#interface eth2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable IPv4 LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#mpls l2-circuit vc3 30 68.68.68.68	Configure a Virtual Circuit for PE3. In this example, vc3 is the VC name, 30 is the VC ID, and 68.68.68.68 is the endpoint IP address.

`(config)#mpls l2-circuit vc4 40 69.69.69.69`	Configure another Virtual Circuit for PE3. In this example, `vc4` is the VC name, `40` is the VC ID, and `69.69.69.69` is the endpoint IP address.
`(config-if)#interface eth1`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer 2 mode.
`(config-if)#mpls-l2-circuit vc1 ethernet`	Bind VC3 as an Ethernet circuit.
`(config-if)#mpls-l2-circuit vc2 ethernet`	Bind VC4 as an Ethernet circuit.
`(config-if)#vc-mode standby`	Configure VC mode as standby.
`(config-if)#exit`	Exit interface mode.

PE4

`#configure terminal`	Enter configure mode.
`(config-if)#interface lo`	Identify the loopback interface to configure (`lo`).
`(config-if)#ip address 69.69.69.69/32`	Set the IP address of the loopback interface to `69.69.69.69/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth4`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#ip address 44.0.0.69/24`	Set the IP address of the interface to `44.0.0.69/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf`	Enter the `Router` mode for OSPF.
`(config-router)#network 69.69.69.69/32 area 0` `(config-router)#network 44.0.0.0/24 area 0`	Define the Network on which OSPF runs and associate the area ID (`area 0`) with the interface.
`(config-router)#exit`	Exit `Router` mode and return to `Configure` mode.
`(config)#router ldp`	Enter the `Router` mode for LDP.
`(config-router)#transport-address ipv4 69.69.69.69`	Configure LDP loopback address as transport address.
`(config-router)#pw-status-tlv`	Enable the Pseudowire Status TLV (`pw-status-tlv`).
`(config-router)#targeted-peer-ipv4 68.68.68.68`	Configure LDP targeted peer to PE1.
`(config-router)#targeted-peer-ipv4 69.69.69.69`	Configure LDP targeted peer to PE3.
`(config-router)#exit`	Exit the `Router` mode and return to `Configure` mode.
`(config)#interface eth4`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable IPv4 LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls l2-circuit vc2 20 66.66.66.66`	Configure a Virtual Circuit for PE1. In this example, `vc2` is the VC name, `20` is the VC ID, and `66.66.66.66` is the endpoint IP address.

`(config)#mpls l2-circuit vc4 40 67.67.67.67`	Configure another Virtual Circuit for PE3. In this example, `vc4` is the VC name, `40` is the VC ID, and `66.66.66.66` is the endpoint IP address.
`(config-if)#interface eth1`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer 2 mode.
`(config-if)#mpls-l2-circuit vc2 ethernet`	Bind VC2 as an Ethernet circuit.
`(config-if)#mpls-l2-circuit vc3 ethernet`	Bind VC4 as an Ethernet circuit.
`(config-if)#vc-mode standby`	Configure VC mode as standby.
`(config-if)#exit`	Exit interface mode.

P

`#configure terminal`	Enter configure mode.
`(config-if)#interface lo`	Identify the loopback interface to configure (`lo`).
`(config-if)#ip address 71.71.71.71`	Set the IP address of the loopback interface to `71.71.71.71.`
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter the `Router` mode for LDP.
`(config-router)#transport-address ipv4 71.71.71.71`	Configure loopback address as LDP transport address.
`(config-router)#pw-status-tlv`	Enable the PW Status TLV (`pw-status-tlv`).
`(config-router)#exit`	Exit `Router` mode and return to `Configure` more.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#ip address 11.0.0.71/24`	Set the IP address of `eth0` to `11.0.0.71/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on interface `eth1`.
`(config-if) ip address 22.0.0.71/24`	Set the IP address of the interface to `22.0.0.71/24`.
`(config-if)#enable-ldp ipv4`	Enable IPv4 LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#ip address 33.0.0.71/24`	Set the IP address for the interface to `33.0.0.71/24`.
`(config-if)#enable-ldp ipv4`	Enable IPv4 LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth4`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#ip address 44.0.0.71/24`	Set the IP address for the interface to `44.0.0.71/24`.
`(config-if) enable-ldp ipv4`	Enable IPv4 LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf`	Enter the `Router` mode for OSPF.

(config-router)#network 11.0.0.0/24 area 0 (config-router)#network 22.0.0.0/24 area 0 (config-router)#network 33.0.0.0/24 area 0 (config-router)#network 44.0.0.0/24 area 0 (config-router)#network 71.71.71.71/32 area 0	Configure the Network associations for router P and associate them all with `area 0`.
(config-router)#exit	Exit `Router` mode and return to `Configure` mode.

Validation

To see summary information about the Virtual Circuits, use the following command:

```
#show mpls vc-table
```

The samples below show summary information about the just-configured four virtual circuits.

```
QA66#show mpls vc-table
VC-ID Vlan-ID  Access-Intf  Network-Intf Out Label Tunnel-Label Nexthop      Status
10    N/A      eth2         eth1         52488     52482        68.68.68.68  Active
20    N/A      eth2         eth1         52480     52484        69.69.69.69  Standby

QA67#show mpls vc-table
VC-ID Vlan-ID  Access-Intf  Network-Intf Out Label Tunnel-Label Nexthop      Status
30    N/A      eth1         eth2         52488     52485        68.68.68.68  Standby
40    N/A      eth1         eth2         52487     52481        69.69.69.69  Standby
```

To view detailed configuration information about the L2 Virtual Circuits, including LDP PW status, use the following command:

```
#show lpd mpls-l2-circuit detail
```

An example of the output of this command follows:

```
QA66#show ldp mpls-l2-circuit detail
vcid: 10, type: ethernet, local groupid: 4, remote groupid: 4 (vc is up)
destination: 68.68.68.68, Peer LDP Ident: 68.68.68.68
Local label: 52480, remote label: 52488
Access IF: eth2, Network IF: eth1
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled, Remote Control Word: disabled, Current use: disabled
Local PW Status Capability : enabled
Remote PW Status Capability : enabled
Current PW Status TLV : enabled
Local PW Status :
  Forwarding
  Active
Remote PW Status :
  Forwarding
  Active

vcid: 20, type: ethernet, local groupid: 4, remote groupid: 3 (vc is up)
destination: 69.69.69.69, Peer LDP Ident: 69.69.69.69
Local label: 52481, remote label: 52480
Access IF: eth2, Network IF: eth1
```



```
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled, Remote Control Word: disabled, Current use: disabled
Local PW Status Capability : enabled
Remote PW Status Capability : enabled
Current PW Status TLV : enabled
Local PW Status :
  Not Forwarding
  Active
Remote PW Status :
  Not Forwarding
  Standby
```

Virtual Circuit PW Configuration

To view configuration information about the L2 Virtual Circuits, use the following command:

```
#show mpls l2-circuit
```

An sample of the output of this command follows:

```
MPLS Layer-2 Virtual Circuit: vc1, id: 10
 Endpoint: 68.68.68.68
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: eth2
 Virtual Circuit Type: Ethernet
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit runtime mode is Active

MPLS Layer-2 Virtual Circuit: vc2, id: 20
 Endpoint: 69.69.69.69
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: eth2
 Virtual Circuit Type: Ethernet
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit runtime mode is Active
```

MTU-s with Redundant Spoke Circuits

In this scenario, MTU-s has redundant spoke circuits PW1 and PW2 connected to PE1 and PE2, respectively. User should configure MTU-s so that one PW is Primary and the other as Secondary. With P1 designated as Primary and PW2 designated as Secondary, MTU-s announces that PW1 is in the Active mode and PW2 is in the Standby mode. If PW1 fails, MTU-s performs a switchover by announcing PW2 as Active and PW1 as Standby.

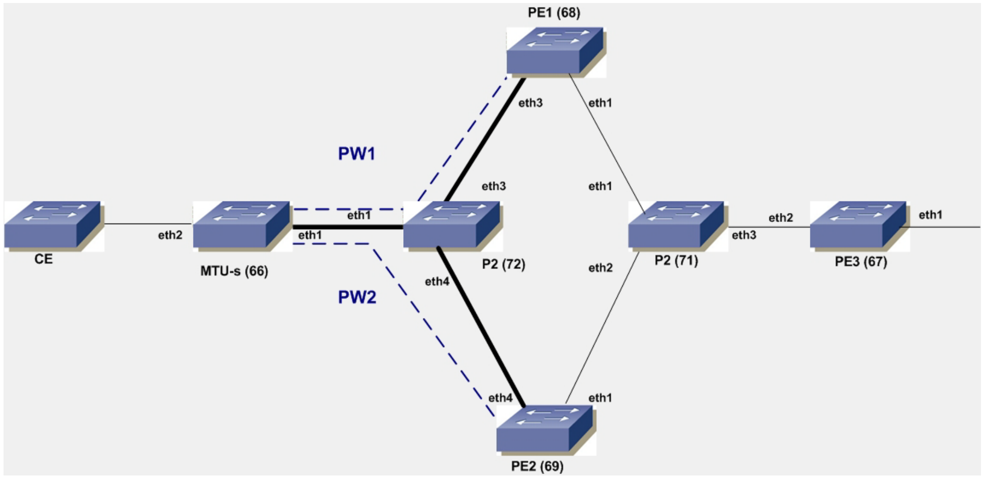


Figure 16-2: MTUs with Redundant Spoke Circuits

MTU-s

`#configure terminal`	Enter configure mode.
`(config-if)#lo`	Identify the loopback interface to configure (`lo`).
`(config-if)#ip address 66.66.66.66/32`	Set the IP address of the loopback interface to `66.96.66.66/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#ip address 11.0.0.66/24`	Set the IP address of the interface to `11.1.1.66./24.`
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf`	Enter the `Router` mode for OSPF.
`(config-router)#network 66.66.66.66/32 area 0` `(config-router)#network 11.0.0.66/24 area 0`	Define the Network on which OSPF runs and associate the area ID (`area 0)` with the interface.
`(config-router)#exit`	Exit `Router` mode and return to `Configure` mode.
`(config)#router ldp`	Enter the `Router` mode for LDP.
`(config-router)#transport-address ipv4 66.66.66.66`	Configure loopback address as LDP transport address.
`(config-router)#pw-status-tlv`	Enable the PW Status TLV `(pw-status-tlv`).
`(config-router)#targeted-peer-ipv4 68.68.68.68`	Configure LDP targeted peer to PE1.
`(config-router)#targeted-peer-ipv4 69.69.69.69`	Configure LDP targeted peer to PE2.
`(config-router)#exit`	Exit `Router` mode and return to `Configure` mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable IPv4 LDP on the interface.
`(config-if)#exit`	Exit interface mode.

(config)#mpls l2-circuit vc1 10 68.68.68.68	Configure a Virtual Circuit to PE1. In this example, vc1 is the VC name, 10 is the VC ID, and 68.68.68.68 is the endpoint IP address.
(config)#mpls l2-circuit vc2 20 69.69.69.69	Configure another Virtual Circuit to PE1. In this example, vc2 is the VC name, 20 is the VC ID, and 69.69.69.69 is the endpoint IP address.
(config-if)#interface eth2	Enter interface mode.
(config-if)#switchport	Switch to Layer 2 mode.
(config-if)#mpls-l2-circuit vc1 ethernet	Bind VC1 as an Ethernet circuit.
(config-if)#mpls-l2-circuit vc2 ethernet secondary	Bind VC2 as secondary.
(config-if)#exit	Exit interface mode.

P1

#configure terminal	Enter configure mode.
(config-if)#interface lo	Identify the loopback interface to configure (lo).
(config-if)#ip address 71.71.71.71	Set the IP address of the loopback interface to 71.71.71.71.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter the Router mode for LDP.
(config-router)#transport-address ipv4 71.71.71.71	Configure loopback address as LDP transport address.
(config-router)#pw-status-tlv	Enable the PW Status TLV (pw-status-tlv).
(config-router)#exit	Exit Router mode and return to Configure mode.
(config)#interface eth1	Enter interface mode.
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#ip address 11.0.0.71/24	Set the IP address of eth1 to 11.0.0.71/24.
(config-if)#enable-ldp ipv4	Enable IPv4 LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface eth3	Enter interface mode.
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#ip address 33.0.0.71/24	Set the IP address for eth3 to 33.0.0.71/24.
(config-if)#enable-ldp ipv4	Enable IPv4 LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface eth4	Enter interface mode.
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#ip address 44.0.0.71/24	Set the IP address for the interface to 44.0.0.71/24.
(config-if)#enable-ldp ipv4	Enable IPv4 LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf	Enter the Router mode for OSPF.

(config-router)#network 71.71.71.71/32 area 0 (config-router)#network 11.0.0.71/24 area 0 (config-router)#network 33.0.0.71/24 area 0 (config-router)#network 44.0.0.71/24 area 0	Configure the Network associations for router P1 and associate them all to `area0`.
(config-router)#exit	Exit `Router` mode and return to `Configure` mode.

Configure PE1

#configure terminal	Enter configure mode.
(config-if)#interface lo	Identify the loopback interface to configure (`lo`).
(config-if)#ip address 68.68.68.68/32	Set the IP address of the loopback interface to `68.68.68.68/32`.
(config-if)#exit	Exit interface mode.
(config)#interface eth3	Enter interface mode.
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#ip address 33.0.0.68/24	Set the IP address of the interface to `33.0.0.68/24`.
(config-if)#exit	Exit interface mode.
(config)#interface eth1	Enter interface mode.
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#ip address 22.0.0.68/24	Set the IP address of the interface to 22`.0.0.68/24`.
(config-if)#exit	Exit interface mode.
(config)#router ospf	Enter the `Router` mode for OSPF.
(config-router)#network 68.68.68.68/32 area 0 (config-router)#network 33.0.0.0/24 area 0 (config-router)#network 22.0.0.0/24 area 0	Define the Network on which OSPF runs and associate the area ID (`area 0`) with the interfaces.
(config-router)#exit	Exit `Router` mode and return to `Configure` mode.
(config)#router ldp	Enter the `Router` mode for LDP.
(config-router)#transport-address ipv4 68.68.68.68	Configure loopback address as LDP transport address.
(config-router)#pw-status-tlv	Enable the PW Status TLV (`pw-status-tlv`).
(config-router)#targeted-peer-ipv4 66.66.66.66	Configure LDP targeted peer to MTU-s.
(config-router)#targeted-peer-ipv4 67.67.67.67	Configure LDP targeted peer to PE3.
(config-router)#exit	Exit `Router` mode and return to `Configure` mode.
(config)#interface eth3	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable IPv4 LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface eth1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable IPv4 LDP on the interface.
(config-if)#exit	Exit interface mode.

`(config)#mpls l2-circuit vc1 10 66.66.66.66`	Configure a Virtual Circuit to MTU-s. In this example, `vc1` is the VC name, `10` is the VC ID, and `66.66.66.66` is the endpoint IP address.
`(config)#mpls vpls vp1 15`	Enter `VPLS` mode and configure VPLS `vp1` with VPLS ID `15`.
`(config-vpls)#signaling ldp`	Enter VPLS signaling LDP mode.
`(config-vpls-sig)#vpls-peer 67.67.67.67`	Configure a VPLS mesh peer to PE3.
`(config-vpls-sig)#exit`	Exit signaling LDP mode.
`(config-vpls)#vpls-vc vc1`	Configure `vc1` as a VPLS spoke peer.
`(config-vpls)#exit`	Exit interface mode.

Configure PE2

`#configure terminal`	Enter configure mode.
`(config-if)#interface lo`	Identify the loopback interface to configure `(lo)`.
`(config-if)#ip address 69.69.69.69/32`	Set the IP address of the loopback interface to `69.69.69.69/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth4`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#ip address 44.0.0.69/24`	Set the IP address of the interface to `44.0.0.69/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#ip address 23.0.0.69/24`	Set the IP address of the interface to `23.0.0.69/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf`	Enter the `Router` mode for OSPF.

`(config-router)#network 69.69.69.69/32 area 0`
`(config-router)#network 44.0.0.0/24 area 0`
`(config-router)#network 23.0.0.0/24 area 0`
	Define the Network on which OSPF runs and associate the area ID (`area 0`) with the interfaces.

`(config-router)#exit`	Exit `Router` mode and return to `Configure` mode.
`(config)#router ldp`	Enter the `Router` mode for LDP.
`(config)#transport-address ipv4 69.69.69.69`	Configure LDP transport address as loopback address.
`(config-router)#pw-status-tlv`	Enable the PW Status TLV (`pw-status-tlv`).
`(config-router)#targeted-peer-ipv4 66.66.66.66`	Configure LDP targeted peer to MTU-s.
`(config-router)#targeted-peer-ipv4 67.67.67.67`	Configure LDP targeted peer to PE3.
`(config-router)#exit`	Exit the `Router` mode and return to `Configure` mode.
`(config)#interface eth4`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable IPv4 LDP on the interface.

`(config-if)#exit`	Exit interface mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable IPv4 LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls l2-circuit vc2 20 66.66.66.66`	Configure a Virtual Circuit to MTU-s. In this example, `vc2` is the VC name, `20` is the VC ID, and `66.66.66.66` is the endpoint IP address.
`(config)#mpls vpls vp1 15`	Configure a VPLS `vp1` with `VPLS ID 15`.
`(config-vpls)#signaling ldp`	Enter VPLS signaling LDP mode.
`(config-vpls-sig)#vpls-peer 67.67.67.67`	Configure a VPLS mesh peer to PE3.
`(config-vpls-sig)#exit`	Exit signaling LDP mode.
`(config-vpls)#vpls-vc vc2`	Configure `vc2` as a VPLS spoke peer.
`(config-vpls)#exit`	Exit `VPLS` mode and return to `Configure` mode.

Configure P2

`#configure terminal`	Enter configure mode.
`(config-if)#interface lo`	Identify the loopback interface to configure `(lo)`.
`(config-if)#ip address 72.72.72.72`	Set the IP address of the loopback interface to `72.72.72.72`.
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter the `Router` mode for LDP.
`(config-router)#transport-address ipv4 72.72.72.72`	Configure loopback address as LDP transport address.
`(config-router)#pw-status-tlv`	Enable the PW Status TLV (`pw-status-tlv`).
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if) ip address 22.0.0.72/24`	Set the IP address of the interface to `22.0.0.72/24`.
`(config-if)#enable-ldp ipv4`	Enable IPv4 LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#ip address 23.0.0.72/24`	Set the IP address for the interface to `23.0.0.72/24`.
`(config-if)#enable-ldp ipv4`	Enable IPv4 LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#ip address 24.0.0.72/24`	Set the IP address of the interface to `24.0.0.72/24`.
`(config-if) enable-ldp ipv4`	Enable IPv4 LDP on the interface.

`(config-if)#exit`	Exit interface mode.
`(config)#router ospf`	Enter the `Router` mode for OSPF.

`(config-router)#network 72.72.72.72/32 area 0`
`(config-router)#network 22.0.0.0/24 area 0`
`(config-router)#network 23.0.0.0/24 area 0`
`(config-router)#network 24.0.0.0/24 area 0`
	Configure the Network associations for router P2 and associate them all with `area 0`.

`(config-router)#exit`	Exit `Router` mode and return to `Configure` mode.

Configure PE3

`#configure terminal`	Enter configure mode.
`(config-if)#interface lo`	Identify the loopback interface to configure (`lo`).
`(config-if)#ip address 67.67.67.67/32`	Set the IP address of the loopback interface to `67.67.67.67/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#ip address 24.0.0.67/24`	Set the IP address of the interface to `24.0.0.67/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf`	Enter the `Router` mode for OSPF.
`(config-router)#network 67.67.67.67/32 area 0` `(config-router)#network 24.0.0.0/24 area 0`	Define the Network on which OSPF runs and associate the area ID (`area 0`) with the interface.
`(config-router)#exit`	Exit `Router` mode and return to `Configure` mode.
`(config)#router ldp`	Enter the `Router` mode for LDP.
`(config-router)#transport-address ipv4 67.67.67.67`	Configure loopback address as LDP transport address.
`(config-router)#pw-status-tlv`	Enable the Pseudowire Status TLV (`pw-status-tlv`).
`(config-router)#targeted-peer-ipv4 68.68.68.68`	Configure LDP targeted peer to PE1.
`(config-router)#targeted-peer-ipv4 69.69.69.69`	Configure LDP targeted peer to PE2.
`(config-router)#exit`	Exit `Router` mode and return to `Configure` mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable IPv4 LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls vpls vp1 15`	Configure VPLS `vp1` with VPLS ID `15`.
`(config-vpls)#signaling ldp`	Enter VPLS signaling LDP mode.
`(config-vpls-sig)#vpls-peer 68.68.68.68`	Configure VPLS mesh peer to PE1.
`(config-vpls-sig)#vpls-peer 69.69.69.69`	Configure VPLS mesh peer to PE2.
`(config-vpls-sig)#exit`	Exit signaling LDP mode.
`(config-vpls)#exit`	Exit `VPLS` mode and return to `Configure` mode.

(config)#interface eth1	Enter interface mode.
(config-if)#switchport	Switch to Layer 2 mode.
(config-if)#mpls-vpls vp1	Bind VPLS vp1 to interface.
(config-if)#exit	Exit interface mode.

Validation

```
QA66#show mpls vc-table
VC-ID  Vlan-ID  Access-Intf Network-Intf Out Label Tunnel-Label Nexthop     Status
10     N/A      eth2        eth1         52488     52482        68.68.68.68 Active
20     N/A      eth2        eth1         52480     52484        69.69.69.69 Standby
```

Note: The first VC is designated as primary and the second as secondary.

```
QA66#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: vc1, id: 10
 Endpoint: 68.68.68.68
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: eth2
 Virtual Circuit Type: Ethernet
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Non-Revertive
 Virtual Circuit runtime mode is active

MPLS Layer-2 Virtual Circuit: vc2, id: 20
 Endpoint: 69.69.69.69
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: eth2
 Virtual Circuit Type: Ethernet
 Virtual Circuit is configured as Secondary
 Virtual Circuit is configured as Non-Revertive
 Virtual Circuit runtime mode is standby
```

The following command displays the Layer 2 Virtual Circuits for MTU-s with the Local and Remote VC Labels:

```
QA66#show ldp mpls-l2-circuit
Transport Client     VC     VC            Local        Remote       Destination
VC ID     Binding    State  Type          VC Label     VC Label     Address
10        eth2       UP     Ethernet      52480        52488        68.68.68.68
20        eth2       UP     Ethernet      52481        52480        69.69.69.69
```

The example below is sample output from this command for the configuration just completed:

```
QA67#show mpls vpls mesh
VPLS-ID     Peer Addr        In-Intf     In-Label    Out-Intf    Out-Label   Lkps/St
15          68.68.68.68      eth2        52480       eth2        52480       2/Up
15          69.69.69.69      eth2        52488       eth2        52488       2/Up
```

Multi-Homed CE with PW Redundancy for VLAN PW

In the following topology diagram, VLAN pseudowires PW1, PW2, PW3 and PW4 are configured for VLAN-100 between PE1-PE3, PE1-PE4, PE2-PE3 and PE2-PE4 respectively. The VC-mode is configured as standby on the access interfaces of PE2 and PE4 so that PW1 is active and used for forwarding. All the other PWs will be in standby mode.

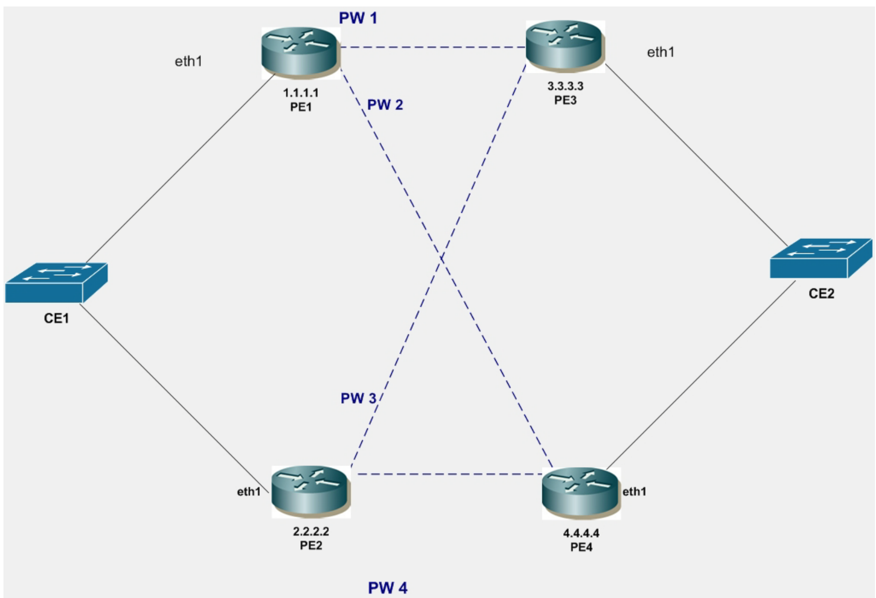


Figure 16-3: Multi-Homed CE with PW Redundancy for VLAN PW

PE1

`#configure terminal`	Enter `Configure` mode for the router.
`(config)#router ldp`	Enter `Router LDP` mode.
`(config-router)#pw-status-tlv`	Configure PW status TLV for PW status signaling.
`(config-router)#targeted-peer ipv4 3.3.3.3`	Configure targeted LDP session to PE3 loopback address.
`(config-router)#targeted-peer ipv4 4.4.4.4`	Configure targeted LDP session to PE4 loopback address.
`(config-router)#exit`	Exit the `Router LDP` mode and return to `Configure` mode.
`(config)#mpls l2-circuit pw1 10 3.3.3.3`	Configure pseudowire PW1 between PE1 and PE3.
`(config)#mpls l2-circuit pw2 20 4.4.4.4`	Configure pseudowire PW2 between PE1 and PE4.
`(config)#bridge 1 protocol ieee vlan-bridge`	Specify the VLAN for bridge 1.
`(config)#vlan database`	Enter the `VLAN Database` mode.
`(config-vlan)#vlan 100 bridge 1`	Configure VLAN 100.
`(config-vlan)#exit`	Exit the `VLAN Database` mode and return to `Configure` mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode.

(config-if)#switchport mode access	Set the switching characteristics of this interface to access mode.
(config-if)#mpls-l2-circuit pw1 vlan 100	Bind the pseudowire PW1 to access interface.
(config-if)#mpls-l2-circuit pw2 vlan 100	Bind the pseudowire PW2 to access interface.
(config-if)#exit	Exit interface mode.
(config)#exit	Exit the `Configure` mode.

PE2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the `Router LDP` mode.
(config-router)#pw-status-tlv	Configure PW status TLV for PW status signaling.
(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted LDP session to PE3 loopback address.
(config-router)#targeted-peer ipv4 4.4.4.4	Configure targeted LDP session to PE4 loopback address.
(config-router)#exit	Exit the `Router LDP` mode and return to `Configure` mode.
(config)#mpls l2-circuit pw3 30 3.3.3.3	Configure pseudowire PW3 between PE2 and PE3.
(config)#mpls l2-circuit pw4 40 4.4.4.4	Configure pseudowire PW4 between PE2 and PE4.
(config)#bridge 1 protocol ieee vlan-bridge	Specify the VLAN for bridge 1.
(config)#vlan database	Enter the `VLAN Database` mode.
(config-vlan)#vlan 100 bridge 1	Configure VLAN 100.
(config-vlan)#exit	Exit the `VLAN Database` mode and return to `Configure` mode.
(config)#interface eth1	Enter interface mode.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#switchport mode access	Set the switching characteristics of this Interface to Access mode.
(config-if)#mpls-l2-circuit pw3 vlan 100	Bind the pseudowire PW3 to access interface.
(config-if)#mpls-l2-circuit pw4 vlan 100	Bind the pseudowire PW4 to access interface.
(config-if)#vc-mode standby vlan 100	Configure VC-mode as standby for VLAN 100. Note: The command for Ethernet PWs is `vc-mode standby`.
(config-if)#exit	Exit interface mode.
(config)#exit	Exit the `Configure` mode.

PE3

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the `Router LDP` mode.
(config-router)#pw-status-tlv	Configure PW status TLV for PW status signaling.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted LDP session to PE1 loopback address.

`(config-router)#targeted-peer ipv4 2.2.2.2`	Configure targeted LDP session to PE2 loopback address.
`(config-router)#exit`	Exit the `Router LDP` mode and return to `Configure` mode.
`(config)#mpls l2-circuit pw1 10 1.1.1.1`	Configure pseudowire PW1 between PE3 and PE1.
`(config)#mpls l2-circuit pw3 30 2.2.2.2`	Configure pseudowire pw2 between PE3 and PE2.
`(config)#bridge 1 protocol ieee vlan-bridge`	Specify the VLAN for bridge 1.
`(config)#vlan database`	Enter the `VLAN Database` mode.
`(config-vlan)#vlan 100 bridge 1`	Configure VLAN 100.
`(config-vlan)#exit`	Exit the `VLAN Database` mode and return to `Configure` mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#switchport mode access`	Set the switching characteristics of this interface to access mode.
`(config-if)#mpls-l2-circuit pw1 vlan 100`	Bind the pseudowire PW1 to access interface.
`(config-if)#mpls-l2-circuit pw3 vlan 100`	Bind the pseudowire PW3 to access interface.
`(config-if)#exit`	Exit interface mode.
`(config)#exit`	Exit the `Configure` mode.

PE4

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter the `Router LDP` mode.
`(config-router)#pw-status-tlv`	Configure PW status TLV for PW status signaling.
`(config-router)#targeted-peer ipv4 1.1.1.1`	Configure targeted LDP session to PE1 loopback address.
`(config-router)#targeted-peer ipv4 2.2.2.2`	Configure targeted LDP session to PE2 loopback address.
`(config-router)#exit`	Exit the `Router LDP` mode and return to `Configure` mode.
`(config)#mpls l2-circuit pw2 20 1.1.1.1`	Configure pseudowire PW2 between PE4 and PE3.
`(config)#mpls l2-circuit pw4 40 2.2.2.2`	Configure pseudowire PW4 between PE4 and PE2.
`(config)#bridge 1 protocol ieee vlan-bridge`	Specify the VLAN for bridge 1.
`(config)#vlan database`	Enter the `VLAN Database` mode.
`(config-vlan)#vlan 100 bridge 1`	Configure VLAN 100.
`(config-vlan)#exit`	Exit the `VLAN Database` mode and return to `Configure` mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode.

`(config-if)#switchport mode access`	Set the switching characteristics of this interface to access mode.
`(config-if)#mpls-l2-circuit pw2 vlan 100`	Bind the pseudowire PW2 to access interface.
`(config-if)#mpls-l2-circuit pw4 vlan 100`	Bind the pseudowire PW4 to access interface.
`(config-if)#vc-mode standby vlan 100`	Configure VC-mode as standby for VLAN 100. Note: The command for Ethernet PWs is `vc-mode standby`.
`(config-if)#exit`	Exit interface mode.
`(config)#exit`	Exit the `Configure` mode.

Remove VC-mode Standby Configuration

PE2

`#configure terminal`	Enter configure mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#no vc-mode standby vlan 100`	Remove VC-mode standby for VLAN 100.
`(config-if)#exit`	Exit interface mode.

Validation

Verify the VPLS Session On DUT

```
PE1#show mpls vc-table
VC-ID  Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label  Nexthop  Status
10      100       eth1          eth2          53121      3             3.3.3.3  Active
20      100       eth1          eth3          53121      3             4.4.4.4  Standby
PE1#show ldp mpls-l2-circuit detail
vcid: 10, type: ethernet, local groupid: 5, remote groupid: 5 (vc is up)
destination: 3.3.3.3, Peer LDP Ident: 3.3.3.3
Local label: 52481, remote label: 53121
Access IF: eth1, Network IF: eth2
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled, Remote Control Word: disabled, Current use: disabled
Local PW Status Capability : enabled
Remote PW Status Capability : enabled
Current PW Status TLV : enabled
Local PW Status :
  Forwarding
  Active
Remote PW Status :
  Forwarding
  Active

vcid: 20, type: ethernet, local groupid: 5, remote groupid: 5 (vc is up)
destination: 4.4.4.4 , Peer LDP Ident: 4.4.4.4
```

```
Local label: 52480, remote label: 53121
Access IF: eth1, Network IF: eth3
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled, Remote Control Word: disabled, Current use: disabled
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
```

MTU-s with PW Redundancy

Follow these basic configuration steps for MTU-s with PW redundancy.

1. Configure VLAN pseudowires PW1 and PW2 between MTU-s and PE1 and MTU-s and PE2.
2. Configure PW1 as primary, PW2 as secondary and VC mode as revertive on MTU-s.
3. Configure VPLS and peer between PE1and PE3, PE2 and PE3.
4. Configure VPLS spoke VC use PW1 on PE1 and VPLS spoke VC use PW2 on PE2.

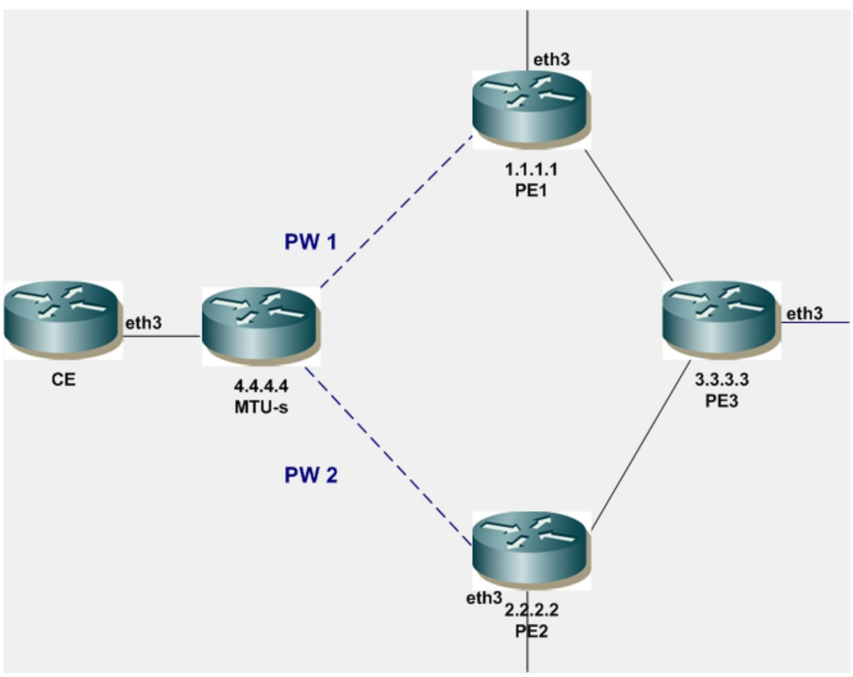


Figure 16-4: MTU-s with PW Redundancy

MTU-s

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter the `Router LDP` mode.

(config-router)#pw-status-tlv	Configure PW status TLV for PW status signaling.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted LDP session to PE1 loopback address.
(config-router)#targeted-peer ipv4 2.2.2.2	Configure targeted LDP session to PE2 loopback address.
(config-router)#exit	Exit the Router LDP mode and return to Configure mode.
(config)#bridge 1 protocol ieee vlan-bridge	Specify the VLAN for bridge 1.
(config)#vlan database	Enter the VLAN database mode.
(config-vlan)#vlan 100 bridge 1	Configure VLAN 100.
(config-vlan)#exit	Exit the VLAN database mode and return to Configure mode.
(config)#mpls l2-circuit pw1 10 4.4.4.4	Configure pseudowire PW1 between MTU-s and PE1
(config)#mpls l2-circuit pw2 20 4.4.4.4	Configure pseudowire PW2 between MTU-s and PE2
(config)#interface eth3	Enter interface mode.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#switchport mode access	Set the switching characteristics of this interface to access mode.
(config-if)#mpls-l2-circuit pw1 vlan 100	Bind the PW1 as primary pseudowire to access interface
(config-if)#mpls-l2-circuit pw2 vlan 100 secondary	Bind the PW2 as secondary pseudowire to access interface
(config-if)#vc-mode revertive vlan 100	Configure VC-mode as revertive.
(config-if)#exit	Enter interface mode.
(config)#exit	Enter configure mode.
#vc-switchover pw1 pw2	Configure VC-switchover to change the forwarding status of active PW1 to standby and standby PW2 to active.

PE1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router LDP mode.
(config-router)#pw-status-tlv	Configure PW status TLV for pseudowire status signaling.
(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted LDP session to PE3 loopback address.
(config-router)#targeted-peer ipv4 4.4.4.4	Configure targeted LDP session to MTU-s loopback address.
(config-router)#exit	Exit the Router LDP mode and return to Configure mode.
(config)#bridge 1 protocol ieee vlan-bridge	Specify the VLAN for bridge 1.
(config)#vlan database	Enter the VLAN Database mode.
(config-vlan)#vlan 100 bridge 1	Configure VLAN 100.
(config-vlan)#exit	Exit the VLAN Database mode and return to Configure mode.
(config)#mpls l2-circuit pw1 10 4.4.4.4	Configure pseudowire PW1 between PE1 and MTU-s.

`(config)#mpls vpls v1 111`	Configure VPLS v1 with ID 111 on PE1.
`(config-vpls)#signaling ldp`	Enter VPLS signaling LDP mode.
`(config-vpls-sig)#vpls-peer 3.3.3.3`	Configure PE3 as VPLS peer
`(config-vpls-sig)#exit`	Exit signaling LDP mode.
`(config-vpls)#vpls-vc pw1 vlan`	Configure PW1 as VLAN VC-Spoke.
`(config-vpls)#exit`	Exit the `VPLS` mode and return to `Configure` mode.
`(config)#interface eth3`	Enter configure mode.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#switchport mode access`	Set the switching characteristics of this interface to access mode.
`(config-if)#mpls-vpls v1`	Bind the VPLS to access interface.
`(config-if)#exit`	Enter interface mode.
`(config)#exit`	Enter configure mode.

PE2

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter the `Router LDP` mode.
`(config-router)#pw-status-tlv`	Configure PW status TLV for pseudowire status signaling.
`(config-router)#targeted-peer ipv4 3.3.3.3`	Configure targeted LDP session to PE3 loopback address.
`(config-router)#targeted-peer ipv4 4.4.4.4`	Configure targeted LDP session to MTU-s loopback address.
`(config-router)#exit`	Exit the `Router LDP` mode and return to `Configure` mode.
`(config)#bridge 1 protocol ieee vlan-bridge`	Specify the VLAN for bridge 1.
`(config)#vlan database`	Enter the `VLAN Database` mode.
`(config-vlan)#vlan 100 bridge 1`	Configure VLAN 100.
`(config-vlan)#exit`	Exit the `VLAN Database` mode and return to `Configure` mode.
`(config)#mpls l2-circuit pw2 20 4.4.4.4`	Configure pseudowire PW2 between PE2 and MTU-s.
`(config)#mpls vpls v1 111`	Configure VPLS v1 with ID 111 on PE2.
`(config-vpls)#signaling ldp`	Enter VPLS signaling LDP mode.
`(config-vpls-sig)#vpls-peer 3.3.3.3`	Configure PW3 as VPLS peer.
`(config-vpls-sig)#exit`	Exit signaling LDP mode.
`(config-vpls)#vpls-vc pw2 vlan`	Configure PW2 as VLAN VC-spoke.
`(config-vpls)#exit`	Exit the `VPLS` mode and return to `Configure` mode.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode.

(config-if)#switchport mode access	Set the switching characteristics of this interface to access mode.
(config-if)#mpls-vpls v1	Bind the VPLS to access interface
(config-if)#exit	Exit interface mode.

PE3

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router LDP mode.
(config-router)#pw-status-tlv	Configure PW status TLV for PW status signaling.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted LDP session to PE1 loopback address.
(config-router)#targeted-peer ipv4 2.2.2.2	Configure targeted LDP session to PE2 loopback address.
(config-router)#exit	Exit the Router LDP mode and return to Configure mode.
(config)#mpls vpls v1 111	Configure VPLS v1 with ID 111 on PE1.
(config-vpls)#signaling ldp	Enter VPLS signaling LDP mode.
(config-vpls-sig)#vpls-peer 1.1.1.1	Configure PE1 as VPLS peer.
(config-vpls-sig)#vpls-peer 2.2.2.2	Configure PE2 as VPLS peer.
(config-vpls-sig)#exit	Exit signaling LDP mode.
(config-vpls)#exit	Exit the VPLS mode and return to Configure mode.
(config)#interface eth3	Enter interface mode.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#switchport mode access	Set the switching characteristics of this interface to access mode.
(config-if)#mpls-vpls v1	Bind the VPLS to access interface.
(config-if)#exit	Enter interface mode.

Remove VC-mode Revertive Configuration

MTU-s

#configure terminal	Enter configure mode.
(config)#interface eth3	Enter interface mode.
(config-if)#no vc-mode revertive vlan 100	Remove VC-mode revertive for VLAN 100.
(config-if)#exit	Enter interface mode.
(config)#exit	Enter configure mode.

Validation

Enter the commands listed in the section below.

Verify the VC-table Session on DUT

```
MTU-s#show mpls vc-table
VC-ID  Vlan-ID  Access-Intf  Network-Intf  Out Label  Tunnel-Label  Nexthop  Status
10      100      eth3          eth1          53121      3            1.1.1.1  Active
20      100      eth3          eth2          53120      3            2.2.2.2  Standby
```

Verify VPLS Session on PE1

```
PE1#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 111
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 Configured interfaces: none
 Mesh Peers:  3.3.3.3 (Up)
 Spoke Peers: pw1 (Up)
```

CHAPTER 17 Multi-Segment Pseudowire Configuration

This chapter contains configurations for Multi-Segment Pseudowires (MS-PW).

For details about the commands used, see the *Label Distribution Protocol Command Reference*.

Overview

An L2VPN (Layer 2 Virtual Private Network) multi-segment pseudowire (MS-PW), also called a switched PW, is a statically- or dynamically-configured set of two or more PW segments that function as a single PW. An MS-PW spans across multiple cores or autonomous systems of the same or different carrier networks.

Multi-segment pseudowires enable a service provider to extend the reach of pseudo-wires across multiple domains. The domains can be autonomous systems under one provider administrative control, IGP areas in one autonomous system, different autonomous systems under the administrative control of two or more service providers, or administratively established pseudowire domains.

The end routers are called terminating PE routers (T-PEs), and the switching routers are called S-PE routers. The S-PE router terminates the tunnels of the preceding and succeeding PW segments in an MS-PW.

The S-PE router switches the control and data planes of the preceding and succeeding PW segments of the MS-PW. An MS-PW is declared to be up when all the single-segment PWs are up.

This document contains the procedures required to accomplish the following tasks:

- Configure signaled VCs (virtual circuits)
- Configure static VCs
- Add FIB entries for static VCs
- Bind Layer 2 VC to physical interfaces (switchport)
- Configure targeted LDP sessions and enable the pseudowire status TLV (pw-status-tlv)
- Enable or Disable LDP and label-switching on interfaces
- Stitch two VCs at an S-PE
- Configure S-PE string descriptions
- Display details of MS-PW associations on an S-PE
- Display the stitching associations configured on an S-PE
- Display the Status, Interface and Label associations for an MS-PW
- Display the configuration of the S-PE for the LDP module.

Topology

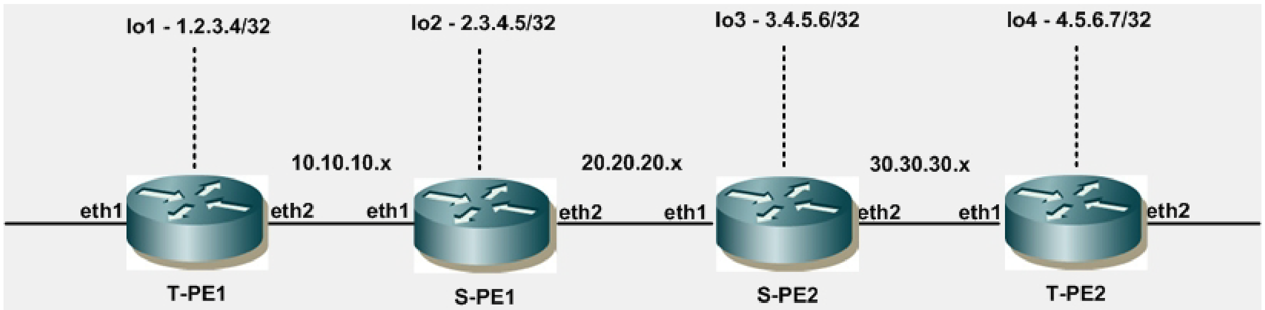


Figure 17-1: MS-PW Configuration

Dynamic MS-PW

T-PE2

`#configure terminal`	Enter Configure mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#ip add 30.30.30.55/24`	Assign an IP address.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Enter Router OSPF mode.
`(config-router)#network 4.5.6.7/32 a 0`	Configure OSPF network.
`(config-router)#network 30.30.30.0/24 a 0`	Configure OSPF network.
`(config-router)#exit`	Exit Router OSPF mode and return to Configure mode.
`(config)#router ldp`	Enter Router LDP mode.
`(config-router)#pw-status-tlv`	Enable pw-status-tlv.
`(config-router)#targeted-peer ipv4 3.4.5.6`	Configure targeted-peer LDP session to S-PE2.
`(config-router)#exit`	Exit Router LDP mode and return to Configure mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#label-switching`	Enable label-switching on the interface connected to S-PE.
`(config-if)#enable-ldp ipv4`	Enable LDP on the interface connected to S-PE.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls l2-circuit c3 300 3.4.5.6 passive`	Configure dynamic-passive pseudowire.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#switchport`	Change eth2 to Layer 2 interface.
`(config-if)#mpls-l2-circuit c3 ethernet`	Bind the PW to the Layer 2 interface connected to CE router.
`(config-if)#exit`	Exit interface mode.

S-PE2

`#configure terminal`	Enter Configure mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#ip add 20.20.20.54/24`	Assign an IP address.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#ip add 30.30.30.54/24`	Assign an IP address.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Enter Router OSPF mode.
`(config-router)#network 3.4.5.6/32 a 0`	Configure OSPF network.
`(config-router)#network 20.20.20.0/24 a 0`	Configure OSPF network.
`(config-router)#network 30.30.30.0/24 a 0`	Configure OSPF network.
`(config-router)#exit`	Exit Router OSPF mode and return to Configure mode.
`(config)#router ldp`	Enter Router LDP mode.
`(config-router)#pw-status-tlv`	Enable pw-status-tlv.
`(config-router)#targeted-peer ipv4 4.5.6.7`	Configure targeted-peer LPD session to T-PE2.
`(config-router)#targeted-peer ipv4 2.3.4.5`	Configure targeted-peer LDP session to S-PE1.
`(config-router)#exit`	Exit Router LDP mode and return to Configure mode.
`(config)#mpls l2-circuit c3 300 4.5.6.7`	Configure dynamic PW for circuit c3.
`(config)#mpls l2-circuit c2 200 2.3.4.5`	Configure dynamic PW for circuit c2.
`(config)#mpls ms-pw-stitch sp2 c2 c3`	Stitch the two PWs.
`(config)#mpls ms-pw sp2 from-mpls-pc2-to-mpls-pc4`	Configure S-PE description.

S-PE1

`#configure terminal`	Enter Configure mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#ip add 10.10.10.53/24`	Assign an IP address.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#ip add 20.20.20.52/24`	Assign an IP address.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Enter Router OSPF mode.
`(config-router)#network 2.3.4.5/32 a 0`	Configure OSPF network.
`(config-router)#network 10.10.10.0/24 a 0`	Configure OSPF network.
`(config-router)#network 20.20.20.0/24 a 0`	Configure OSPF network.
`(config-router)#exit`	Exit Router OSPF mode and return to Configure mode.
`(config)#router ldp`	Enter Router LDP mode.

(config-router)#pw-status-tlv	Enable pw-status-tlv.
(config-router)#targeted-peer ipv4 3.4.5.6	Configure targeted-peer LDP session to S-PE2.
(config-router)#targeted-peer ipv4 1.2.3.4	Configure targeted-peer LDP session to T-PE1.
(config-router)#exit	Exit Router LDP mode and return to Configure mode.
(config)#mpls l2-circuit c2 200 3.4.5.6	Configure dynamic PW for circuit c2.
(config)#mpls l2-circuit c1 100 1.2.3.4	Configure dynamic PW for circuit c1.
(config)#mpls ms-pw-stitch sp2 c1 c2	Stitch the two pseudowires.
(config)#mpls ms-pw sp1 from-mpls-pc1-to-mpls-pc3	Configure S-PE description.

Static MS-PW

S-PE1

(config)#mpls l2-circuit c1 100 1.2.3.4 manual	Configure static pseudowire.
(config)#mpls ms-pw-stitch sp1 c1 c2 mtu 1500 ethernet	Stitch the two pseudowires, one of which is signaled and the other is manual.
(config)#mpls l2-circuit-fib-entry 100 101 201 1.2.3.4 eth3 c2	Add FIB entry for the static PW. c2 is the PW to which it has to be stitched at S-PE1.

T-PE1

#configure terminal	Enter Configure mode.
(config)#interface eth1	Enter interface mode.
(config-if)#ip add 10.10.10.51/24	Assign IP address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Enter Router OSPF mode.
(config-router)#network 1.2.3.4/32 a 0	Configure OSPF network.
(config-router)#network 10.10.10.0/24 a 0	Configure OSPF network.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#router ldp	Enter Router LDP mode
(config-router)#pw-status-tlv	Enable pw-status-tlv.
(config-router)#targeted-peer ipv4 2.3.4.5	Configure targeted-peer LDP session to S-PE1.
(config-router)#exit	Exit Router LDP mode and return to Configure mode.
(config)#interface eth1	Enter interface mode.
(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)#mpls l2-circuit c1 100 2.3.4.5	Configure dynamic PW.

`(config)#interface eth2`	Enter interface mode.
`(config-if)#switchport`	Configure eth2 as a Layer 2 interface.
`(config-if)#mpls-l2-circuit c1 ethernet`	Bind the PW to the Layer 2 interface connected to CE router.
`(config-if)#exit`	Exit interface mode.

T-PE1

`(config)#mpls l2-circuit c1 100 2.3.4.5 manual`	Configure static pseudowire.
`(config)#mpls l2-circuit-fib-entry 100 201 101 2.3.4.5 eth1 eth2`	Adding FIB entry for the static PW created, after binding it to the access interface (eth2).

Validation

Display LDP Configuration on S-PE

```
#show ldp ms-pw sp2
S-PE description: from-mpls-pc3-to-mpls-pc4
==================================================================
id:                         200                 id:                         300
Endpoint:                   2.3.4.5             Endpoint:                   4.5.6.7
Role:                       Passive             Role:                       Passive
Group ID:                   4                   Groups ID:                  4
Rmt Flt/Clr sndr(S-PE):     0.0.0.0             Rmt Flt/Clr sndr(S-PE):     0.0.0.0
==================================================================
```

Display All Stitching Associations Configured on S-PE

```
#show mpls ms-pw
==================================================================
MS-PW  Segment-1  VC1-ID  Segment-2  VC2-ID
sp2    c2         200     c3         300
```

Display Details of MS-PW Association on S-PE

```
#show mpls ms-pw sp2
==================================================================
VC1:              c2              VC2:            c3
id:               200             id:             300
Endpoint:         2.3.4.5         Endpoint:       4.5.6.7
Control Word:     0               Control Word:   0
VC Type:          Ethernet        VC Type:        Ethernet
Owner:            Signaled        Owner:          Signaled
Role:             Active          Role:           Active
==================================================================
```

Display Status, Interface and Label Associations for an MS-PW

```
#show mpls ms-pw sp2 vc-table
==================================================================
In VC   Vlan-ID   In-lbl   Nw-Intf         Out-Lbl        Status      Tunnel-lbl
c2         N/A    53125    eth4            53120          Active      3
c3         N/A    53124    eth3            53124          Active      3
==================================================================
```

`#show mpls ms-pw sp1 vc-table` (in case of stitched dynamic and static PW at S-PE)

```
==================================================================
In VC    Vlan-ID     In-Lbl      Nw-Intf      Out-Lbl   Status  Tunnel- Lbl
```

```
c1         N/A        101        eth4        53120      Active  3
c2         N/A       53120       eth3        201        Active  3
===================================================================
```

Display Details of MS-PW Association on S-PE if One VC is Manual

`#show mpls ms-pw sp1` (in case of one signaled VC and one manual VC, stitched)

```
===================================================================
VC1:                c1              VC2:                c2
id:                 100             id:                 200
Endpoint:           1.2.3.4         Endpoint:           3.4.5.6
Control Word:       0               Control Word:       0
VC Type:            Ethernet        VC Type:            Ethernet
Owner:              Manual          Owner:              Signaled
Role:               Active          Role:               Active
===================================================================
```

Display VC-Table and PW-Status Individual Segments of a MS-PW

```
#show ldp mpls-l2-circuit
===================================================================
Transport Client     VC     VC            Local       Remote      Destination
VC ID     Binding    State  Type          VC Label    VC Label    Address
200       eth4       UP     Ethernet      53125       53124       2.3.4.5
300       eth3       UP     Ethernet      53124       53120       4.5.6.7
===================================================================

#show mpls vc-table
===================================================================
VC-ID  Vlan-ID  Access-Intf  Network-Intf  Out Label  Tunnel-Label  Nexthop    Status
200      N/A      eth4         eth3          53124         3        2.3.4.5    Active
300      N/A      eth3         eth4          53120         3        4.5.6.7    Active
===================================================================
```

CHAPTER 18 SAToP Configuration

Structure agnostic TDM over PSN (SATop) emulates an end-to-end TDM circuit over MPLS. This feature creates a pseudowire between two end points over MPLS as defined in RFC 4447.

SAToP Pseudowire Creation

This procedure show how to establish the pseudowire between provider edge routers. The configuration assumes that you are running the `ospfd`, `ldpd`, `mstpd`, `nsm`, and `imi` daemons.

Topology

Figure 18-1: Three router topology for PW creation

Rtr1

`#configure terminal`	Enter configure mode
`(config)#hostname Rtr1`	Configure the name of the host as Rtr1
`Rtr1(config)#interface eth7`	Enter interface mode
`Rtr1(config-if)#ip address 1.1.1.1/24`	Assign IP address 1.1.1.1 to the interface
`Rtr1(config-if)#exit`	Exit interface mode
`Rtr1(config)#int lo`	Enter interface mode
`Rtr1(config-if)#ip address 2.2.2.2/32`	Assign an IP address to the loopback interface
`Rtr1(config-if)#exit`	Exit interface mode
`Rtr1(config)#router ospf`	Enter OSPF router mode
`Rtr1(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
`Rtr1(config-router)#network 1.1.1.1/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`Rtr1(config-router)#exit`	Exit OSPF router mode
`Rtr1(config)#router ldp`	Enter LDP router mode
`Rtr1(config-router)#targeted-peer ipv4 4.4.4.4`	Configure the target peer IP address

Rtr1(config-router-targeted-peer)#exit	Exit LDP targeted peer mode
Rtr1(config-router)#exit	Exit LDP router mode
Rtr1(config)#int eth7	Enter interface mode
Rtr1(config-if)#enable-ldp ipv4	Enable the LDP protocol on eth1
Rtr1(config-if)#label-switching	Enable label switching on interface eth1
Rtr1(config-if)#exit	Exit the LDP configuration mode
Rtr1(config)#int tdm 5	Enter interface mode
Rtr1(config-if)#tdm payload bytes 200	Configure the TDM payload bytes to 200
Rtr1(config-if))#mpls-l2-circuit vc1 tdm-T1	Bind the T1 interface to the pseudowire
Rtr1(config-if)#exit	Exit interface configuration mode
Rtr1(config)#mpls l2-circuit vc1 10 4.4.4.4	Configure a Virtual Circuit for PE1. In this example, vc1 is the VC name, 10 is the VC ID, and 4.4.4.4 is the Endpoint IP address.

Rtr2

#configure terminal	Enter configure mode
(config)#hostname Rtr2	Configure the name of the host as Rtr2
Rtr2(config)#int eth2	Enter interface mode
Rtr2(config-if)#ip address 1.1.1.2/24	Assign IP address 1.1.1.2 to the interface
Rtr2(config-if)#exit	Exit interface mode
Rtr2(config)#int eth3	Enter interface mode
Rtr2(config-if)#ip address 5.5.5.1/24	Assign IP address 5.5.5.1 to the interface
Rtr2(config-if)#exit	Exit interface mode.
Rtr2(config)#int lo	Enter interface mode
Rtr2(config-if)#ip address 3.3.3.3/32	Assign IP address 3.3.3.3 to the loopback interface
Rtr2(config-if)#exit	Exit interface mode
Rtr2(config)#router ospf	Enter OSPF router mode
Rtr1(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
Rtr2(config-router)#network 1.1.1.2/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
Rtr2(config-router)#network 5.5.5.1/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
Rtr2(config-router)#exit	Exit OSPF router mode
Rtr2(config)#int eth2	Enter interface mode
Rtr2(config-if)#enable ldp ipv4	Enable the LDP protocol on eth1
Rtr2(config-if)#label switching	Enable label switching on interface eth1
Rtr2(config-if)#exit	Exit interface mode

`Rtr2(config)#int eth3`	Enter interface mode
`Rtr2(config-if)#enable ldp ipv4`	Enable the LDP protocol on eth2
`Rtr2(config-if)#label switching`	Enable label switching on interface eth2
`Rtr2(config-if)#exit`	Exit interface mode

Rtr3

`#configure terminal`	Enter configure mode
`(config)#hostname Rtr3`	Configure the name of the host as Rtr3
`Rtr3(config)#interface eth2`	Enter interface mode
`Rtr3(config-if)#ip address 5.5.5.2/24`	Assign IP address 5.5.5.2 to the interface
`Rtr3(config-if)#exit`	Exit interface mode
`Rtr3(config)#int lo`	Enter interface mode
`Rtr3(config-if)#ip address 4.4.4.4/32`	Assign an IP address to the loopback interface
`Rtr3(config-if)#exit`	Exit interface mode
`Rtr3(config)#router ospf`	Enter OSPF router mode
`Rtr3(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
`Rtr3(config-router)#network 5.5.5.2/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`Rtr3(config-router)#exit`	Exit OSPF router mode
`Rtr3(config)#router ldp`	Enter LDP router mode
`Rtr3(config-router)#targeted-peer ipv4 2.2.2.2`	Configure the target peer IP address
`Rtr3(config-router-targeted-peer)#exit`	Exit LDP router mode
`Rtr3(config-router)#exit`	Exit the router mode
`Rtr3(config)#int eth2`	Enter interface mode
`Rtr3(config-if)#enable-ldp ipv4`	Enable the LDP protocol on eth1
`Rtr3(config-if)#label-switching`	Enable label switching on interface eth1
`Rtr3(config-if)#exit`	Exit interface mode
`Rtr3(config)#int tdm 5`	Enter interface mode
`Rtr1(config-if)#tdm payload bytes 200`	Configure the TDM payload bytes to be 200 bytes
`Rtr3(config-if))#mpls-l2-circuit vc1 tdm-T1`	Bind the T1 interface to the pseudowire
`Rtr3(config-if)#exit`	Exit interface mode
`Rtr3(config)#mpls l2-circuit vc1 10 2.2.2.2`	Configure a Virtual Circuit for PE1. In this example, vc1 is the VC name, 10 is the VC ID, and 2.2.2.2 is the endpoint IP address.

Validation

Verify on Rtr1 or Rtr3 that the LDP session is operating and that the PW is set-up successfully.

```
rtr1#show ldp session
Peer IP Address          IF Name    My Role           State                KeepAlive
4.4.4.4                  eth7        Passive          OPERATIONAL          30
3.3.3.3                  eth7        Passive          OPERATIONAL          30
rtr1#show ldp mpls-l2-circuit
Transport Client    VC          VC             Local         Remote        Destination
VC ID     Binding   State       Type           VC Label      VC Label      Address
10        tdm5      UP          tdm-E1         16            16            4.4.4.4
```

Handling Defects and Alarms

Once a pseudowire has been set up, the CE-bound IWF begins to receive SAToP packets and to store their payload in the jitter buffer but continues to transmit the “all ones” pattern to its TDM attachment circuit. This intermediate state persists until a preconfigured amount of TDM data (usually half of the jitter buffer) has been received in consecutive SAToP packets or until a preconfigured intermediate state timer (started when the PW setup is completed) expires.

If the CE-bound SAToP IWF detects the loss of a preconfigured number of consecutive packets or if the intermediate state timer expires before the required amount of TDM data has been received, it enters its packet loss state. While in this state, the local PSN-bound SAToP IWF should mark every packet it transmits with the R bit set. The CE-bound SAToP IWF leaves this state and transitions to the normal one once a preconfigured number of consecutive valid SAToP packets have been received. (Successfully reordered packets contribute to the count of consecutive packets.)

In addition to the packet loss state of the CE-bound SAToP IWF, it may detect the following defects:

- Stray packets
- Malformed packets
- Excessive packet loss rate
- Buffer overrun
- Remote packet loss.

Stray packets may be detected by the PSN and PW demultiplexing layers. When RTP is used, the SSRC field in the RTP header may be used for this purpose as well. Stray packets must be discarded by the CE-bound IWF, and their detection must not affect mechanisms for detection of packet loss.

Malformed packets are detected by mismatch between the expected packet size (taking the value of the L bit into account) and the actual packet size inferred from the PSN and PW demultiplexing layers. When RTP is used, lack of correspondence between the PT value and that allocated for this direction of the PW MAY also be used for this purpose. Malformed in-order packets MUST be discarded by the CE-bound IWF and replacement data generated as with lost packets.

Excessive packet loss rate is detected by computing the average packet loss rate over a configurable amount of times and comparing it with a preconfigured threshold. Buffer overrun is detected in the normal operation state when the jitter buffer of the CE-bound IWF cannot accommodate newly arrived SAToP packets.

Remote packet loss is indicated by reception of packets with their Rbit set.

Topology

See Figure 18-1.

Rtr1

`#configure terminal`	Enter configure mode
`(config)#hostname Rtr1`	Configure the name of the host as Rtr1
`Rtr1(config)#interface eth7`	Enter interface mode
`Rtr1(config-if)#ip address 1.1.1.1/24`	Assign IP address 1.1.1.1 to the interface
`Rtr1(config-if)#exit`	Exit interface mode
`Rtr1(config)#int lo`	Enter interface mode
`Rtr1(config-if)#ip address 2.2.2.2/32`	Assign an IP address to the loopback interface
`Rtr1(config-if)#exit`	Exit interface mode
`Rtr1(config)#router ospf`	Enter OSPF router mode
`Rtr1(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
`Rtr1(config-router)#network 1.1.1.1/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`Rtr1(config-router)#exit`	Exit OSPF router mode
`Rtr1(config)#router ldp`	Enter LDP router mode
`Rtr1(config-router)#targeted-peer ipv4 4.4.4.4`	Configure the target peer IP address
`Rtr1(config-router-targeted-peer)#exit`	Exit LDP router mode
`Rtr1(config-router)#exit`	Exit OSPF router mode
`Rtr1(config)#int eth7`	Enter interface mode
`Rtr1(config-if)#enable-ldp ipv4`	Enable the LDP protocol on eth1
`Rtr1(config-if)#label-switching`	Enable label switching on interface eth1
`Rtr1(config-if)#exit`	Exit interface mode
`Rtr1(config)#int tdm 5`	Enter interface mode
`Rtr1(config-if)#tdm payload bytes 200`	Configure the TDM payload bytes to 200
`Rtr1(config-if)#jitter-buffer-size 300`	Configure the jitter-buffer size to 300
`Rtr1 (config-if)#timer error-set malformed-packets 3000`	Configure the value to detect malformed packets
`Rtr1(config-if)#timer error-clear malformed-packets 8000`	Configure the value to clear malformed packets
`Rtr1 (config-if)#timer error-set buffer-overrun 3000`	Configure the value to detect buffer overrun
`Rtr1(config-if)#timer error-clear buffer-overrun 3000`	Configure the value to clear buffer overrun
`Rtr1(config-if)#timer error-set packet-loss 3000`	Configure the value to detect packet-loss
`Rtr1(config-if)#timer error-clear packet-loss 3000`	Configure the value to clear packet-loss

`Rtr1(config-if)#timer error-set excessive-packet-loss-rate 3000`	Configure the value to detect excessive-packet-loss-rate
`Rtr1(config-if)#timer error-clear excessive-packet-loss-rate 3000`	Configure the value to clear excessive-packet-loss-rate
`Rtr1(config-if)#timer error-set stray-packets 3000`	Configure the value to detect stray-packets
`Rtr1 (config-if)#timer error-clear stray-packets 3000`	Configure the value to clear stray-packets
`Rtr1 (config-if)#timer error-set remote-packet-loss 3000`	Configure the value to detect remote-packet-loss 3000
`Rtr1 (config-if)#timer error-clear remote-packet-loss 3000`	Configure the value to clear remote-packet-loss 3000
`Rtr1(config-if))#mpls-l2-circuit vc1 tdm-T1`	Bind the T1 interface to the pseudowire
`Rtr1(config-if)#exit`	Exit interface configuration mode
`Rtr1(config)#mpls l2-circuit vc1 10 4.4.4.4`	Configure a Virtual Circuit for PE1. In this example, vc1 is the VC name, 10 is the VC ID, and 4.4.4.4 is the Endpoint IP address.

Rtr2

`#configure terminal`	Enter configure mode
`(config)#hostname Rtr2`	Configure the name of the host as Rtr2
`Rtr2(config)#int eth2`	Enter interface mode.
`Rtr2(config-if)#ip address 1.1.1.2/24`	Assign IP address 1.1.1.2 to the interface
`Rtr2(config-if)#exit`	Exit interface mode.
`Rtr2(config)#int eth3`	Enter interface mode.
`Rtr2(config-if)#ip address 5.5.5.1/24`	Assign IP address 5.5.5.1 to the interface
`Rtr2(config-if)#exit`	Exit interface mode.
`Rtr2(config)#int lo`	Enter interface mode
`Rtr2(config-if)#ip address 3.3.3.3/32`	Assign IP address 3.3.3.3 to the loopback interface
`Rtr2(config-if)#exit`	Exit interface mode.
`Rtr2(config)#router ospf`	Enter OSPF router mode
`Rtr2(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.
`Rtr2(config-router)#network 1.1.1.2/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`Rtr2(config-router)#network 5.5.5.1/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`Rtr2(config-router)#exit`	Exit OSPF router mode
`Rtr2(config)#int eth2`	Enter interface mode
`Rtr2(config-if)#enable ldp ipv4`	Enable the LDP protocol on eth1

`Rtr2(config-if)#label switching`	Enable label switching on interface eth1.
`Rtr2(config-if)#exit`	Exit interface mode
`Rtr2(config)#int eth3`	Enter interface mode
`Rtr2(config-if)#enable ldp ipv4`	Enable the LDP protocol on eth2
`Rtr2(config-if)#label switching`	Enable label switching on interface eth2.
`Rtr2(config-if)#exit`	Exit interface mode.

Rtr3

`#configure terminal`	Enter configure mode
`(config)#hostname Rtr3`	Configure the name of the host as Rtr3
`Rtr3(config)#interface eth2`	Enter interface mode.
`Rtr3(config-if)#ip address 5.5.5.2/24`	Assign IP address 5.5.5.2 to the interface
`Rtr3(config-if)#exit`	Exit interface mode
`Rtr3(config)#int lo`	Enter interface mode
`Rtr3(config-if)#ip address 4.4.4.4/32`	Assign an IP address to the loopback interface
`Rtr3(config-if)#exit`	Exit interface mode
`Rtr3(config)#router ospf`	Enter OSPF router mode
`Rtr3(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
`Rtr3(config-router)#network 5.5.5.2/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`Rtr3(config-router)#exit`	Exit OSPF router mode
`Rtr3(config)#router ldp`	Enter LDP router mode
`Rtr3(config-router)#targeted-peer ipv4 2.2.2.2`	Configure the target peer IP address
`Rtr3(config-router-targeted-peer)#exit`	Exit LDP router mode
`Rtr3(config-router)#exit`	Exit the router mode
`Rtr3(config)#int eth2`	Enter interface mode
`Rtr3(config-if)#enable-ldp ipv4`	Enable the LDP protocol on eth1
`Rtr3(config-if)#label-switching`	Enable label switching on interface eth1
`Rtr3(config-if)#exit`	Exit interface mode
`Rtr3(config)#int tdm 5`	Enter interface mode
`Rtr3(config-if)#jitter-buffer-size 300`	Configure the jitter buffer of the size to 300
`Rtr3(config-if)#timer error-set malformed-packets 3000`	Configure the value to detect malformed packets

Rtr3(config-if)#timer error-clear malformed-packets 8000	Configure the value to clear malformed packets
Rtr3(config-if)#timer error-set buffer-overrun 3000	Configure the value to detect buffer overrun
Rtr3(config-if)#timer error-clear buffer-overrun 8000	Configure the value to clear buffer overrun
Rtr3(config-if)#timer error-set packet-loss 3000	Configure the value to detect packet-loss
Rtr3(config-if)#timer error-clear packet-loss 8000	Configure the value to clear packet-loss
Rtr3(config-if)#timer error-set excessive-packet-loss-rate 3000	Configure the value to detect excessive-packet-loss-rate
Rtr3(config-if)#timer error-clear excessive-packet-loss-rate 8000	Configure the value to clear excessive-packet-loss-rate
Rtr3(config-if)#timer error-set stray-packets 3000	Configure the value to detect stray-packets
Rtr3(config-if)#timer error-clear stray-packets 8000	Configure the value to clear stray-packets
Rtr3(config-if)#timer error-set remote-packet-loss 3000	Configure the value to detect remote-packet-loss to 3000
Rtr3(config-if)#timer error-clear remote-packet-loss 8000	Configure the value to clear remote-packet-loss to 3000
Rtr3(config-if))#mpls-l2-circuit vc1 tdm-T1	Bind the T1 interface to the pseudowire
Rtr3(config-if)#exit	Exit interface mode
Rtr1(config)#mpls l2-circuit vc1 10 2.2.2.2	Configure a Virtual Circuit for PE1. In this example, vc1 is the VC name, 10 is the VC ID, and 2.2.2.2 is the Endpoint IP address.

Validation

1. Verify the details on Rtr3.

```
Rtr3#show tdm error-detection-timers interface tdm5

packet_loss_set_period                     = 3000ms
stray_packets_set_period                   = 3000ms
malformed_packets_set_period               = 3000ms
excessive_packet_loss_rate_set_period      = 3000ms
buffer_overrun_set_period                  = 3000ms
remote_packet_loss_set_period              = 3000ms
packet_loss_clear_period                   = 8000ms
stray_packets_clear_period                 = 8000ms
malformed_packets_clear_period             = 8000ms
excessive_packet_loss_rate_clear_period    = 8000ms
buffer_overrun_clear_period                = 8000ms
remote_packet_loss_clear_period            = 8000ms
```

2. See the values of TDM interface parameters such as TDM payload bytes and pseudowire control word information.

```
Rtr3#show tdm interface tdm5

tdm-name  status  type  bitrate   payload_bytes  buffer-size  PW_Id control_word
```



```
----------------------------------------------------------------------------
tdm5      UP      E1    2048 kb/s 200          500
```

3. Show the statistics counter of following from the CE-bound IWF:

```
rtr3#show tdm satop-statistics ce-bound interface tdm5
==========================================================
   Interface tdm5
==========================================================
forwarded packets             = 0
fbp_drop_packets              = 0
out_of_window_packets         = 0
buffer_overun_dropped_packets = 0
window_switchover             = 0
buffer_overun_events          = 0
stray_packets                 = 0
malformed_packets             = 0
cw_ais_drop_packets           = 0
multiple_packets              = 0
mpls_drop_packets             = 0
denied_packets                = 0
out_of_sequence_packets       = 0
out_of_band_cas_packets       = 0
rdi_dropped_packets           = 0
rai_packets                   = 0
```

CHAPTER 19 MPLS-TP Protocols

MPLS-TP is a simplified subset of MPLS and supports transport-type functions:

- Point-to-point unidirectional tunnels, point-to-point associated tunnels, and point-to-point co-routed tunnels
- IP-based identifiers for MPLS TP identifiers
- LSP static provisioning of transport paths via the management plane
- BFD-MPLS or data link OAM static provisioning of transport paths via the management plane
- Supported transport services: IPv4 traffic, pseudowire
- LSPs are manually set up
- Protection switching driven by OAM monitors

MPLS TP excludes the following functions of MPLS:

- Penultimate Hop Popping (PHP)
- Label-Switched Paths (LSP) merge
- Equal Cost Multi Path (ECMP)
- MPLS-TP does not require MPLS control plane capabilities

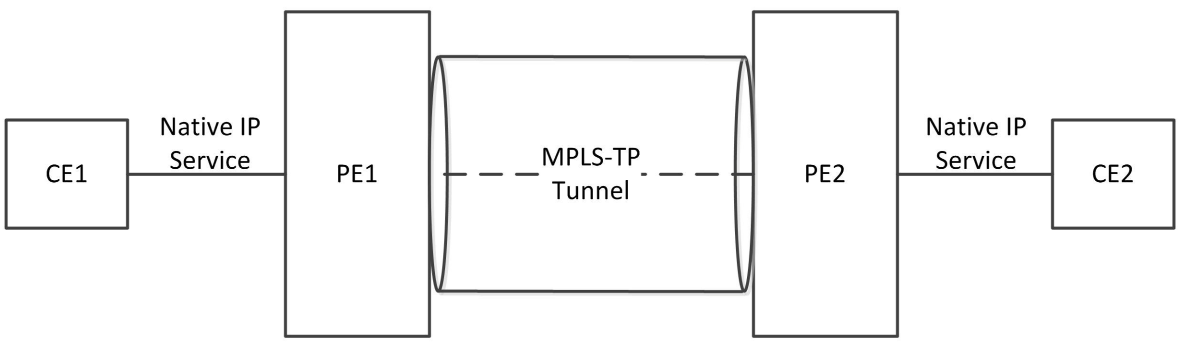


Figure 19-1: Native IP service over MPLS-TP

CHAPTER 20 MPLS-TP Tunnel Architecture

Three types of tunnels are supported in the MPLS-TP framework: unidirectional tunnel; co-routed bidirectional tunnel; associated bidirectional tunnel. Label Switch Paths (LSP) hold transport paths that contain MPLS forwarding information. The following sections provide operational overviews and configuration guidelines:

- MPLS-TP Tunnels Types
- MPLS-TP Label Switched Path
- MPLS-TP Tunnel Configuration Guidelines

MPLS-TP Tunnels Types

A *Tunnel* is the top level container for MPLS transport paths (referred to as LSPs) from a source to a destination. Label Switched Path (LSP) is the logical transport operating from a source to a destination. Each tunnel may have at least one LSP. Tunnels could be unidirectional or bidirectional depending on their underlying LSPs. MPLS-TP Framework (RFC 5921) defines three types of tunnels based on the direction property:

- Unidirectional Tunnel
- Co-routed Bidirectional Tunnel
- Associated Bidirectional Tunnel

Unidirectional Tunnel

Unidirectional MPLS-TP tunnels operate in a single direction from an east node to a west node (source to destination). A unidirectional tunnel has at least one protected unidirectional LSP, which is also referred to as the “forward LSP”.

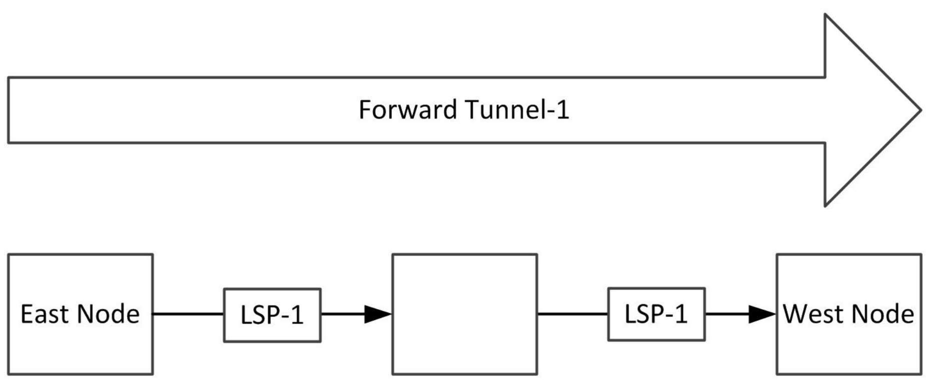


Figure 20-1: Unidirectional Tunnel

Co-routed Bidirectional Tunnel

A Co-routed tunnel has at least one bidirectional LSP. A bidirectional LSP has one forward component and one reverse component. Both components traverse the same nodes and links in either direction end to end, from the source node to destination node. Each node on the path of the Co-routed tunnel maintains the binding between the forward and reverse components for its LSP.

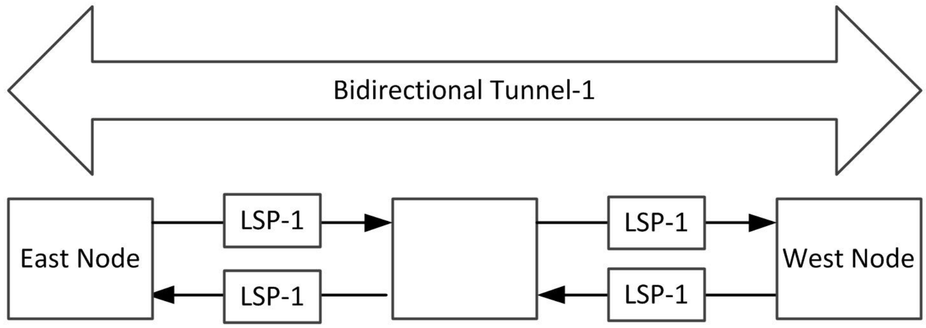


Figure 20-2: Co-routed Tunnel

Associated Bidirectional Tunnel

Associated tunnels support bidirectional data flow with two unidirectional tunnels: one forward tunnel and one reverse tunnel. These tunnels are associated via LSPs.

Each tunnel of an associated-group has at least one unidirectional LSP, which consists of one forward component and one reverse component. The forward and reverse components may traverse either different nodes or different links on the same node, or the same link on the same set of nodes. In the example shown below, the structure is similar to the Co-routed tunnel. Two tunnels are “Associated” at the East node, the West node and at all overlapping nodes.

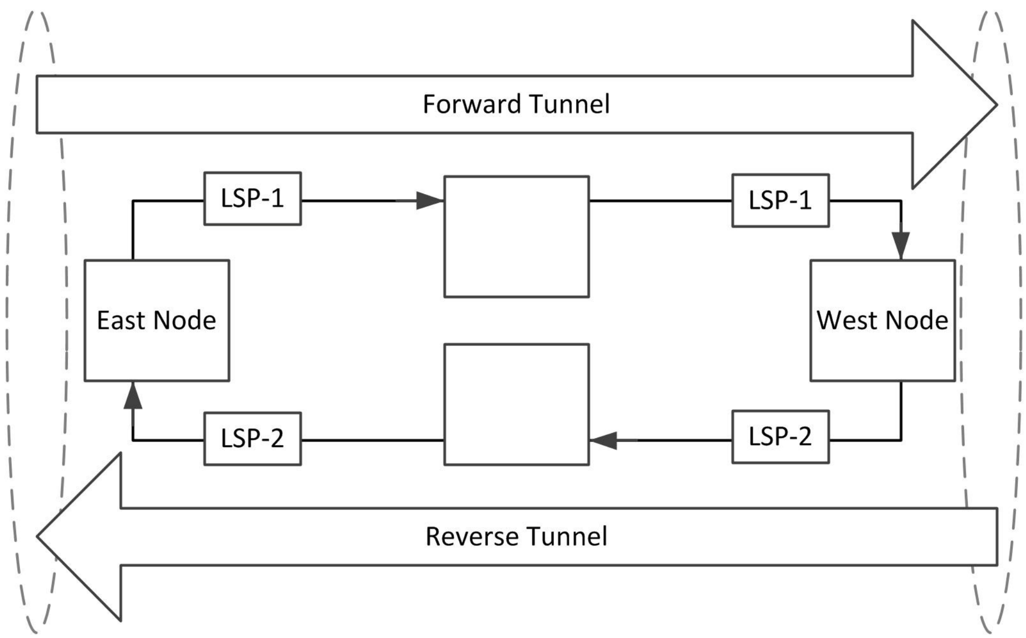


Figure 20-3: Associated Tunnel

MPLS-TP Label Switched Path

Each tunnel can contain one primary Label Switched Path (LSP).There can only be one primary LSP. (Backup LSPs are not supported.) LSPs contain the following information:

NHLFE Entry. NHLFE entry represents the forward-component of an LSP on ingress and the reverse component of LSP on egress (for bidirectional LSPs) and it is represented by the three tuple parameters {out-interface, out-label, next hop MAC}. All the parameters are taken from user configuration.Since next hop MAC is optional parameter, when it is not supplied through configuration, the broadcast MAC address (FF:FF:FF:FF:FF:FF) is assumed.

ILM Entry and Reverse ILM Entry. ILM represents the Incoming Label Map. ILM is a logical table that is indexed by the incoming interface and label. An ILM entry specifies behavior for processing labeled packets that arrive on MPLS core and egress nodes.

- On core nodes, the behavior is swap the labels.
- On egress nodes, the behavior is pop the label and process the native packet.
- For bidirectional LSPs, ILM entries perform the label-pop implement forward component of LSPs on the egress and reverse components of LSPs on ingress.
- ILM entries performing label-swap implement the forward and reverse components of LSPs on transit/core nodes.

Table lists the tunnel modes.

Table 20-1: Tunnel Modes

Tunnel Mode	Ingress		Transit		Egress	
	Forward Path	*Reverse Path*	*Forward Path*	*Reverse Path*	*Forward Path*	*Reverse Path*
Unidirectional	NHLFE	N.A.	ILM	N.A.	ILM	N.A.
Co-Routed	NHLFE	ILM	ILM	ILM	ILM	NHLFE
Associated	NHLFE	ILM	ILM	ILM	ILM	NHLFE

Note: In the case of Associated Tunnels, FWD and REV paths come from LSPs of two different tunnels.

MPLS-TP Tunnel Configuration Guidelines

Following are the basic configurations that must be completed before configuring any type of tunnel:

- Configure global and node identifiers for nodes at the NSM level.
- Configure MPLS-TP provider identifiers for the nodes at the interface level.

CHAPTER 21 MPLS-TP Tunnel Configurations

This chapter provides configuration examples for the MPLS-TP tunnel modes.

Configuring Tunnels Using IETF Identifiers

Topology

The procedures in this section use the topology in Figure 21-1.

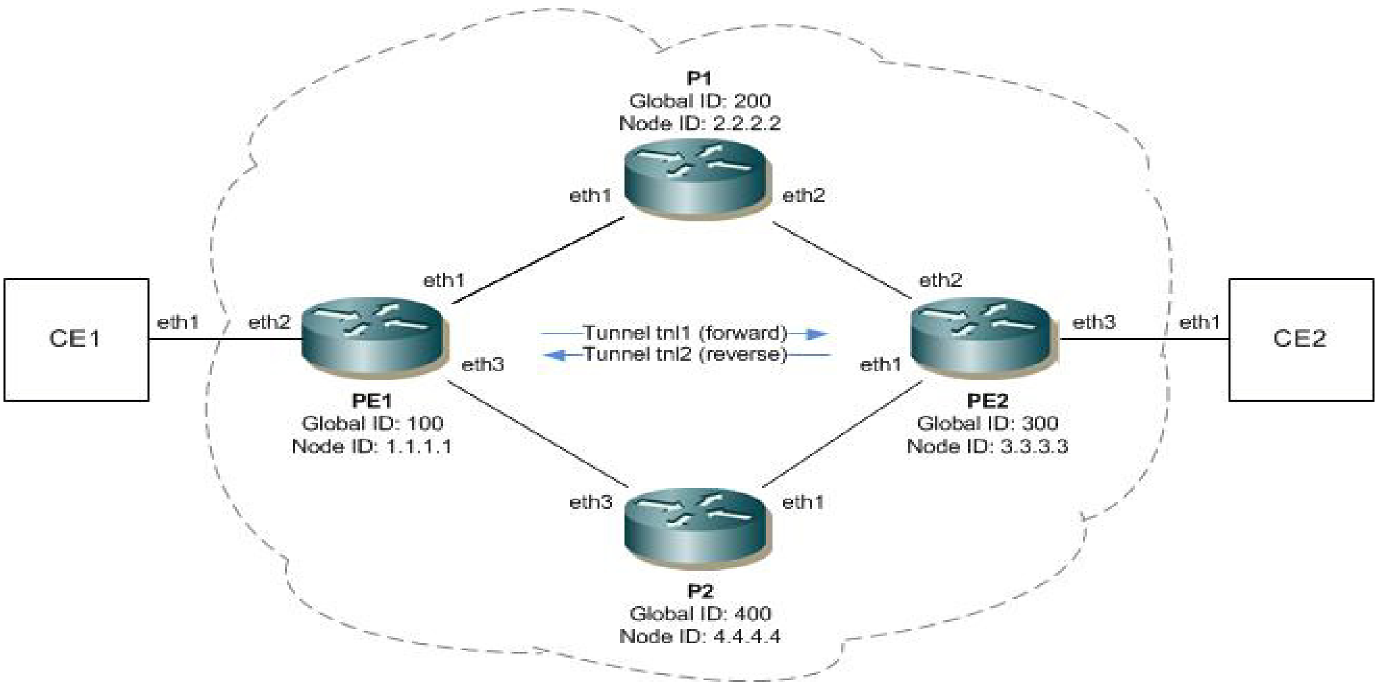


Figure 21-1: MPLS-TP Tunnel Topology (IETF)

Unidirectional Tunnel

PE1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 100 node-id 1.1.1.1`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as provider and set the local identifier to 10.1.1.1.

`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#nhlfe-entry 1001 eth1`	Configure the NHLFE entry as push.

P1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 200 node-id 2.2.2.2`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 10.1.1.2`	Configure the interface as provider and set the local identifier to 10.1.1.2.
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface eth2 as provider interface and the interface local ID as 30.1.1.1.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 1001 eth1 swap 1002 eth2`	Configure the ILM entry as swap.

PE2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 300 node-id 3.3.3.3`	Configure the global identifier and node identifier.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 30.1.1.2`	Configure the interface as provider and set the local identifier to 30.1.1.2.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 1002 eth2 pop`	Configure the ILM entry as pop.

Validation

PE1

```
PE1#sh mpls-tp tunnel

<===============================================================================>
 Tunnel-id              : 1                  Tunnel-Name          : tnl1
```

```
 Source Global-Id      : 100              Source Node-Id      : 1.1.1.1
 Destination Global-Id : 300              Destination Node-Id : 3.3.3.3
 Role  : Source                           Tunnel Index        : 1
 Mode  : UNIDIRECTIONAL                   Tunnel State        : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001               Outgoing-Interface : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
```

P1

```
P1#show mpls-tp tunnel

<================================================================================>
 Tunnel-id             : 1                Tunnel-Name         : tnl1
 Source Global-Id      : 100              Source Node-Id      : 1.1.1.1
 Destination Global-Id : 300              Destination Node-Id : 3.3.3.3
 Role  : Transit                          Tunnel Index        : 1
 Mode  : UNIDIRECTIONAL                    Tunnel State        : UP

     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1001               Incoming-Interface  : eth1
       ILM-Index      : 1                         Cross-Connect-Index : 1
       Outgoing-Label : 1002               Outgoing-Interface  : eth2
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
```

PE2

```
PE2#show mpls-tp tunnel

 Tunnel-id             : 1                Tunnel-Name         : tnl1
 Source Global-Id      : 100              Source Node-Id      : 1.1.1.1
 Destination Global-Id : 300              Destination Node-Id : 3.3.3.3
 Role  : Destination                      Tunnel Index        : 1
 Mode  : UNIDIRECTIONAL                   Tunnel State        : UP

    Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1002               Incoming-Interface  : eth2
       ILM-Index      : 1                  Cross-Connect-Index : 1
       Status : UP
```

Co-Routed Bi-Directional Tunnel

PE1 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp global-id 100 node-id 1.1.1.1	Configure the global identifier and node identifier.
(config)#interface eth1	Enter interface mode for eth1.

(config-if)#mpls-tp provider-interface 10.1.1.1	Configure the interface as provider and set the local identifier to 10.1.1.1.
(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name tnl1	Set the tunnel name.
(config-tnl)#tunnel-mode bidirectional	Make the tunnel bidirectional.
(config-bidir-tnl)#forward-path nhlfe-entry 1001 eth1	Configure the NHLFE entry to push the label at ingress for the forward path.
(config-bidir-tnl)#reverse-path ilm-entry 2002 eth1 pop	Configure the ILM entry to pop the label at egress for the reverse path.

P1 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp global-id 200 node-id 2.2.2.2	Configure the global identifier and node identifier.
(config)#interface eth1	Enter interface mode for eth1.
(config-if)#mpls-tp provider-interface 10.1.1.2	Configure the interface as provider and set the local identifier to 10.1.1.2
(config)#interface eth2	Enter interface mode for eth2.
(config-if)#mpls-tp provider-interface 30.1.1.1	Configure the interface as provider and set the local identifier to 20.1.1.1.
(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name tnl1	Set the tunnel name.
(config-tnl)#tunnel-mode bidirectional	Make the tunnel bidirectional.
(config-bidir-tnl)#forward-path ilm-entry 1001 eth1 swap 1002 eth2	Configure the ILM entry to swap the label at transit for the forward path.
(config-bidir-tnl)#reverse-path ilm-entry 2001 eth2 swap 2002 eth1	Configure the ILM entry to swap the label at transit for the reverse path.

PE2 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp global-id 300 node-id 3.3.3.3	Configure the global identifier and node identifier.
(config)#interface eth2	Enter interface mode for eth2
(config-if)#mpls-tp provider-interface 30.1.1.2	Configure the interface as provider and set the local identifier to 20.1.1.2.
(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name tnl1	Set the tunnel name.
(config-tnl)#tunnel-mode bidirectional	Make the tunnel bidirectional.

(config-bidir-tnl)#forward-path ilm-entry 1002 eth2 pop	Configure the NHLFE entry to push the label at ingress for the forward path.
(config-bidir-tnl)#reverse-path nhlfe-entry 2001 eth2	Configure the ILM entry to pop the label at egress for the reverse path.

Validation

PE1

```
PE1#show mpls-tp tunnel

<===============================================================================>
 Tunnel-id             : 1               Tunnel-Name         : tnl1
 Source Global-Id      : 100             Source Node-Id      : 1.1.1.1
 Destination Global-Id : 300             Destination Node-Id : 3.3.3.3
 Role  : Source                          Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)     Tunnel State        : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001             Outgoing-Interface : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2002             Incoming-Interface  : eth1
       ILM-Index      : 1                        Cross-Connect-Index : 2
       Status : UP
<===============================================================================>
```

P1

```
P1#show mpls-tp tunnel

<===============================================================================>
 Tunnel-id             : 1               Tunnel-Name         : tnl1
 Source Global-Id      : 100            Source Node-Id      : 1.1.1.1
 Destination Global-Id : 300           Destination Node-Id : 3.3.3.3
 Role  : Transit                         Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)     Tunnel State        : UP

     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1001             Incoming-Interface  : eth1
       ILM-Index      : 1                        Cross-Connect-Index : 1
       Outgoing-Label : 1002             Outgoing-Interface  : eth2
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 2001             Incoming-Interface  : eth2
       ILM-Index      : 2                       Cross-Connect-Index : 2
       Outgoing-Label : 2002            Outgoing-Interface  : eth1
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
   : N/A
       Status : UP
```

```
<===============================================================================>
```

PE2

```
PE2#show mpls-tp tunnel

<===============================================================================>
  Tunnel-id              : 1                 Tunnel-Name          : tnl1
 Source Global-Id       : 100               Source Node-Id       : 1.1.1.1
 Destination Global-Id : 300                Destination Node-Id : 3.3.3.3
 Role   : Destination                       Tunnel Index         : 1
 Mode   : COROUTED(bidirectional)           Tunnel State         : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1002                Incoming-Interface   : eth2
       ILM-Index      : 1                               Cross-Connect-Index : 1
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2001                  Outgoing-Interface : eth2
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
   : N/A
       Status : UP
<===============================================================================>
```

Associated Bi-Directional Tunnel

In this configuration, the associated tunnel reverse path travels in different nodes.

PE1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 100 node-id 1.1.1.1`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as provider and set the local identifier to 10.1.1.1.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#mpls-tp provider interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 20.1.1.1.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#nhlfe-entry 1001 eth1`	Configure the NHLFE entry to push label at ingress for the forward path.

(config)#mpls-tp tunnel 2 source 300 3.3.3.3 destination 100 1.1.1.1	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name tnl2	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#ilm-entry 2002 eth3 pop	Configure the ILM entry to pop the label at ingress for the reverse path.
(config)#mpls-tp associate fwd-tunnel tnl1 rev-tunnel tnl2	Associate the forward and reverse tunnels.

P1 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp global-id 200 node-id 2.2.2.2	Configure the global identifier and node identifier.
(config)#interface eth1	Enter interface mode for eth1.
(config-if)#mpls-tp provider-interface 10.1.1.2	Configure the interface as provider and set the local identifier to 10.1.1.2
(config)#interface eth2	Enter interface mode for eth2.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure the interface as provider and set the local identifier to 20.1.1.1
(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name tnl1	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#ilm-entry 1001 eth1 swap 1002 eth2	Configure the ILM entry to swap the label at transit for the forward path.

P2 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp global-id 400 node-id 4.4.4.4	Configure the global identifier and node identifier.
(config)#interface eth1	Enter interface mode for eth1.
(config-if)#mpls-tp provider-interface 60.1.1.1	Configure the interface as provider and set the local identifier to 60.1.1.1
(config-if)#exit	Exit interface mode.
(config)#interface eth3	Enter interface mode.
(config-tnl)#mpls-tp provider-interface 20.1.1.2	Configure the interface as provider and set the local identifier to 20.1.1.2
(config-if)#exit	Exit interface mode.
(config-tnl)#mpls-tp tunnel 2 source 300 3.3.3.3 destination 100 1.1.1.1	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name tnl2	Set the tunnel name.

`(config-tnl)#tunnel-mode undirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 2001 eth1 swap 2002 eth3`	Configure the ILM entry to swap the label at transit for the forward path.

PE2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 300 node-id 3.3.3.3`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 20.1.1.2`	Configure the interface as provider and set the local identifier to 20.1.1.2
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 1002 eth2 pop`	Configure the ILM entry to pop the label for the forward path at egress.
`(config)#mpls-tp tunnel 2 source 300 3.3.3.3 destination 100 1.1.1.1`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl2`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#nhlfe-entry 2001 eth1`	Configure NHFLE entry to push the label for the reverse path at egress.
`(config)#mpls-tp associate fwd-tunnel tnl2 rev-tunnel tnl1`	Associate the forward and reverse tunnels.

Validation

PE1

```
PE1#show mpls-tp tunnel
<=============================================================================>
 Tunnel-id              : 1                 Tunnel-Name          : tnl1
 Source Global-Id       : 100               Source Node-Id       : 1.1.1.1
 Destination Global-Id  : 300               Destination Node-Id  : 3.3.3.3
 Role   : Source                            Tunnel Index         : 1
 Mode   : ASSOCIATED(unidirectional)        Tunnel State         : UP
 Associated-Tunnel    : tnl2
     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001                 Outgoing-Interface : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
```



```
<==========================================================================>
 Tunnel-id              : 2              Tunnel-Name         : tnl2
 Source Global-Id       : 300            Source Node-Id      : 3.3.3.3
 Destination Global-Id : 100             Destination Node-Id : 1.1.1.1
 Role  : Destination                     Tunnel Index        : 2
 Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
 Associated-Tunnel   : tnl1

     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2002             Incoming-Interface  : eth3
       ILM-Index      : 1                Cross-Connect-Index : 2
       Status : UP
```

P1

```
P1#show mpls-tp tunnel

<=========================================================================>
 Tunnel-id              : 1              Tunnel-Name         : tnl1
 Source Global-Id       : 100            Source Node-Id      : 1.1.1.1
 Destination Global-Id : 300             Destination Node-Id : 3.3.3.3
 Role  : Transit                         Tunnel Index        : 1
 Mode  : UNIDIRECTIONAL                   Tunnel State        : UP
     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1001             Incoming-Interface  : eth1
       ILM-Index      : 1                       Cross-Connect-Index : 1
       Outgoing-Label : 1002             Outgoing-Interface  : eth2
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
```

P2

```
P2#show mpls-tp tunnel

<=========================================================================>
 Tunnel-id              : 2              Tunnel-Name         : tnl2
 Source Global-Id       : 300            Source Node-Id      : 3.3.3.3
 Destination Global-Id : 100             Destination Node-Id : 1.1.1.1
 Role  : Transit                         Tunnel Index        : 2
 Mode  : UNIDIRECTIONAL                  Tunnel State        : UP

     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 2001             Incoming-Interface  : eth1
       ILM-Index      : 2                Cross-Connect-Index : 1
       Outgoing-Label : 2002             Outgoing-Interface  : eth3
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
```

PE2

```
PE2#show mpls-tp tunnel

<=========================================================================>
 Tunnel-id              : 2              Tunnel-Name         : tnl2
 Source Global-Id       : 300            Source Node-Id      : 3.3.3.3
 Destination Global-Id : 100             Destination Node-Id : 1.1.1.1
```

```
    Role   : Source                          Tunnel Index         : 2
    Mode   : ASSOCIATED(unidirectional)      Tunnel State         : UP
    Associated-Tunnel    : tnl1

        Forward-Path : NHLFE   <OPCODE : Push>
          Outgoing-Label : 2001                 Outgoing-Interface : eth1
          NHLFE Index    : 1
          BW-class       : N/A
          Status : UP

   <=============================================================================>
    Tunnel-id              : 1               Tunnel-Name          : tnl1
    Source Global-Id       : 100             Source Node-Id       : 1.1.1.1
    Destination Global-Id : 300              Destination Node-Id : 3.3.3.3
    Role   : Destination                     Tunnel Index         : 1
    Mode   : ASSOCIATED(unidirectional)      Tunnel State         : UP
    Associated-Tunnel    : tnl2

        Reverse-Path : ILM   <OPCODE : Pop>
          Incoming-Label : 1002                 Incoming-Interface  : eth2
          ILM-Index      : 1                    Cross-Connect-Index : 1
          Status : UP
```

Configuring Tunnels Using ITU-T Identifiers

Topology

The procedures in this section use the topology in Figure 21-2.

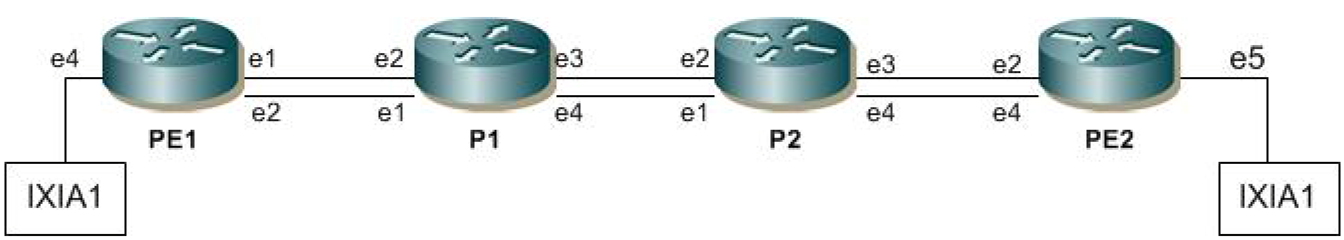


Figure 21-2: MPLS-TP Tunnel Topology (ITUT-T)

Unidirectional Tunnel

Forward Tunnel

PE1 (NSM)

`#configure terminal`	Enter configure mode
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 1.1.1.1`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as provider and set the local identifier to 10.1.1.1

`(config)#mpls-tp tunnel 2 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name tnl_as_fwd`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#nhlfe-entry 1001 eth1`	Configure the NHFE entry to push the label at ingress for the forward path.

P1 (NSM)

`#configure terminal`	Enter configure mode
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 2.2.2.2`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth2`	Enter interface mode for eth2
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 20.1.1.1
`(config)#interface eth3`	Enter interface mode for eth3
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1
`(config)#mpls-tp tunnel 2 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name tnl_as_fwd`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 1001 eth2 swap 1002 eth3`	Configure the ILM entry to swap the label at transit for the forward path

P2 (NSM)

`#configure terminal`	Enter configure mode
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 3.3.3.3`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth2`	Enter interface mode for eth2
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 20.1.1.1
`(config)#interface eth3`	Enter interface mode for eth3
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1
`(config)#mpls-tp tunnel 2 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name tnl_as_fwd`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 1002 eth2 swap 1003 eth3`	Configure the ILM entry to swap the label at transit for the forward path

PE2 (NSM)

`#configure terminal`	Enter configure mode
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 4.4.4.4`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth2`	Enter interface mode for eth2
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as provider and set the local identifier to 10.1.1.1
`(config)#mpls-tp tunnel 2 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name tnl_as_fwd`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 1003 eth2 pop`	Configure the ILM entry to pop the label for the forward path at egress

Validation

PE1

```
#sh mpls-tp tunnel tnl_as_fwd
 Tunnel-id             : 2                Tunnel-Name         : tnl_as_fwd
 Source ICC-Oper-ID    : INAIRTEL         Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL         Destination Node-Id : 4.4.4.4
 Role  : Source                           Tunnel Index        : 2
 Mode  : UNIDIRECTIONALTunnel State         : UP
 Associated-Tunnel   : tnl_as_rev

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001               Outgoing-Interface : eth1
       NHLFE Index    : 3
       BW-class       : N/A
       Status : UP
     ----------------------------------------------------------
      MEG Index       : 2              ME Index        : 11
     ----------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
```

P1

```
#sh mpls-tp tunnel tnl_as_fwd
 Tunnel-id             : 2                Tunnel-Name         : tnl_as_fwd
 Source ICC-Oper-ID    : INAIRTEL         Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL         Destination Node-Id : 4.4.4.4
 Role  : Transit                          Tunnel Index        : 2
 Mode  : UNIDIRECTIONALTunnel State         : UP
 Associated-Tunnel   : tnl_as_rev

     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1001               Incoming-Interface  : eth2
       ILM-Index      : 3                  Cross-Connect-Index : 3
       Outgoing-Label : 1002               Outgoing-Interface  : eth3
       NHLFE Index    : 3
       BW-class       : N/A
```



```
    Status : UP
  -----------------------------------------------------------
   MEG Index       : 2              ME Index        : 22
  -----------------------------------------------------------
     Lock          : Disabled
     Loopback      : Disabled
```

P2

```
#sh mpls-tp tunnel tnl_as_fwd
 Tunnel-id              : 2                 Tunnel-Name          : tnl_as_fwd
 Source ICC-Oper-ID     : INAIRTEL          Source Node-Id       : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL           Destination Node-Id : 4.4.4.4
 Role  : Transit                            Tunnel Index         : 2
 Mode  : UNIDIRECTIONALTunnel State           : UP
 Associated-Tunnel   : tnl_as_rev

     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1002                 Incoming-Interface  : eth2
       ILM-Index      : 6                    Cross-Connect-Index : 3
       Outgoing-Label : 1003                 Outgoing-Interface  : eth3
       NHLFE Index    : 3
       BW-class       : N/A
       Status : UP
     -----------------------------------------------------------
      MEG Index       : 2              ME Index        : 33
     -----------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
```

PE2

```
#sh mpls-tp tunnel tnl_as_fwd
 Tunnel-id              : 2                 Tunnel-Name          : tnl_as_fwd
 Source ICC-Oper-ID     : INAIRTEL          Source Node-Id       : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL           Destination Node-Id : 4.4.4.4
 Role  : Destination                        Tunnel Index         : 2
 Mode  : UNIDIRECTIONAL  Tunnel State           : UP
 Associated-Tunnel   : tnl_as_rev

     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1003                 Incoming-Interface  : eth2
       ILM-Index      : 2                    Cross-Connect-Index : 3
       Status : UP
     -----------------------------------------------------------
      MEG Index       : 3              ME Index        : 444
     -----------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
```

Reverse Tunnel

PE2 (NSM)

#configure terminal	Enter configure mode
(config)#mpls-tp itut cc IN icc AIRTEL node-id 4.4.4.4	Configure the country code, carrier code, and node identifier.

(config)#interface eth4	Enter interface mode for eth4
(config-if)#mpls-tp provider-interface 40.1.1.1	Configure the interface as provider and set the local identifier to 40.1.1.1
(config)#mpls-tp tunnel 3 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
(config-tnl)#tunnel-name tnl_as_rev	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#nhlfe-entry 2002 eth4	Configure the NHFE entry to push the label for the reverse path.

P1 (NSM)

#configure terminal	Enter configure mode
(config)#mpls-tp itut cc IN icc AIRTEL node-id 2.2.2.2	Configure the country code, carrier code, and node identifier.
(config)#interface eth1	Enter interface mode for eth1
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure the interface as provider and set the local identifier to 10.1.1.1
(config)#interface eth4	Enter interface mode for eth4
(config-if)#mpls-tp provider-interface 40.1.1.1	Configure the interface as provider and set the local identifier to 40.1.1.1
(config)#mpls-tp tunnel 3 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
(config-tnl)#tunnel-name tnl_as_rev	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#ilm-entry 2003 eth4 swap 2004 eth1	Configure the ILM entry to swap the label at transit for the forward path.

P2 (NSM)

#configure terminal	Enter configure mode
(config)#mpls-tp itut cc IN icc AIRTEL node-id 3.3.3.3	Configure the country code, carrier code, and node identifier.
(config)#interface eth1	Enter interface mode for eth1
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure the interface as provider and set the local identifier to 10.1.1.1
(config)#interface eth4	Enter interface mode for eth3.
(config-if)#mpls-tp provider-interface 40.1.1.1	Configure the interface as provider and set the local identifier to 40.1.1.1
(config)#mpls-tp tunnel 3 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
(config-tnl)#tunnel-name tnl_as_rev	Set the tunnel name.

`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 2002 eth4 swap 2003 eth1`	Configure the ILM entry to swap the label at transit for the forward path.

PE1 (NSM)

`#configure terminal`	Enter configure mode
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 1.1.1.1`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth2`	Enter interface mode for eth2
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 20.1.1.1
`(config)#mpls-tp tunnel 3 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name tnl_as_rev`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 2004 eth2 pop`	Configure the ILM entry to pop the label at egress for the reverse path.

Validation

PE1

```
#sh mpls-tp tunnel tnl_as_rev
 Tunnel-id              : 3               Tunnel-Name          : tnl_as_rev
 Source ICC-Oper-ID     : INAIRTEL        Source Node-Id       : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL         Destination Node-Id : 1.1.1.1
 Role   : Destination                     Tunnel Index         : 3
 Mode   : UNIDIRECTIONALTunnel State        : UP
 Associated-Tunnel    : tnl_as_fwd

     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2004              Incoming-Interface  : eth2
       ILM-Index      : 2                 Cross-Connect-Index : 4
       Status : UP
      ---------------------------------------------------------
MEG Index       : 2             ME Index        : 11
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
```

P1

```
#sh mpls-tp tunnel tnl_as_rev
 Tunnel-id              : 3               Tunnel-Name          : tnl_as_rev
 Source ICC-Oper-ID     : INAIRTEL        Source Node-Id       : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL         Destination Node-Id : 1.1.1.1
 Role   : Transit                         Tunnel Index         : 3
 Mode   : UNIDIRECTIONALTunnel State        : UP
 Associated-Tunnel    : tnl_as_fwd

     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 2003              Incoming-Interface  : eth4
```

```
        ILM-Index      : 4                  Cross-Connect-Index : 4
        Outgoing-Label : 2004               Outgoing-Interface  : eth1
        NHLFE Index    : 4
        BW-class       : N/A
        Status : UP
      ---------------------------------------------------------
       MEG Index       : 3              ME Index        : 222
      ---------------------------------------------------------
         Lock          : Disabled
         Loopback      : Disabled
```

P2

```
#sh mpls-tp tunnel tnl_as_rev
 Tunnel-id              : 3                Tunnel-Name          : tnl_as_rev
 Source ICC-Oper-ID    : INAIRTEL         Source Node-Id       : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL         Destination Node-Id : 1.1.1.1
 Role  : Transit                           Tunnel Index         : 3
 Mode  : UNIDIRECTIONALTunnel State          : UP
 Associated-Tunnel   : tnl_as_fwd

     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 2002               Incoming-Interface  : eth4
       ILM-Index      : 7                  Cross-Connect-Index : 4
       Outgoing-Label : 2003               Outgoing-Interface  : eth1
       NHLFE Index    : 4
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 3              ME Index        : 333
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
```

PE2

```
#sh mpls-tp tunnel tnl_as_rev
 Tunnel-id              : 3                Tunnel-Name          : tnl_as_rev
 Source ICC-Oper-ID    : INAIRTEL         Source Node-Id       : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL         Destination Node-Id : 1.1.1.1
 Role  : Source                            Tunnel Index         : 3
 Mode  : UNIDIRECTIONALTunnel State          : UP
 Associated-Tunnel   : tnl_as_fwd

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2002               Outgoing-Interface : eth4
       NHLFE Index    : 4
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 2              ME Index        : 44
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
```


Co-Routed Bi-Directional Tunnel

PE1 (NSM)

`#configure terminal`	Enter configure mode
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 1.1.1.1`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as provider and set the local identifier to 10.1.1.1
`(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name tnl_co`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path nhlfe-entry 3001 eth1`	Configure the NHFE entry to push the label at ingress for the forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 4002 eth1 pop`	Configure the ILM entry to pop the label for the reverse path.

P1 (NSM)

`#configure terminal`	Enter configure mode
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 2.2.2.2`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth2`	Enter interface mode for eth2
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 20.1.1.1
`(config)#interface eth3`	Enter interface mode for eth3
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1
`(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name tnl_co`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 3001 eth2 swap 3002 eth3`	Configure the ILM entry to swap the label at transit for the forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 4001 eth3 swap 4002 eth2`	Configure the ILM entry to swap the label at transit for the reverse path.

P2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 3.3.3.3`	Configure the country code, carrier code, and node identifier.

`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 20.1.1.1
`(config)#interface eth3`	Enter interface mode for eth3
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1
`(config)#mpls-tp tunnel 2 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name tnl_co`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 3002 eth2 swap 3003 eth3`	Configure the ILM entry to swap the label at transit for the forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 4000 eth3 swap 4001 eth2`	Configure the ILM entry to swap the label at transit for the reverse path.

PE2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 4.4.4.4`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth2`	Enter interface mode for eth2
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 20.1.1.1
`(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name tnl_co`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 3003 eth2 pop`	Configure the ILM entry to pop the label for the forward path at egress.
`(config-bidir-tnl)#reverse-path nhlfe-entry 4000 eth2`	Configure the NHFE entry to push the label for the reverse path at egress.

Validation

PE1

```
#sh mpls-tp tunnel tnl_co
PE1#sh mpls-tp tunnel tnl_co
 Tunnel-id              : 1                Tunnel-Name          : tnl_co
 Source ICC-Oper-ID     : INAIRTEL         Source Node-Id       : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL          Destination Node-Id : 4.4.4.4
 Role   : Source                           Tunnel Index         : 1
 Mode   : COROUTED(bidirectional)          Tunnel State         : UP


      Forward-Path : NHLFE   <OPCODE : Push>
        Outgoing-Label : 3001               Outgoing-Interface : eth1
        NHLFE Index    : 1
```



```
      BW-class       : N/A
      Status : UP
    Reverse-Path : ILM   <OPCODE : Pop>
      Incoming-Label : 4002             Incoming-Interface  : eth1
      ILM-Index      : 1                Cross-Connect-Index : 2
      Status : UP
    ---------------------------------------------------------
     MEG Index       : 1             ME Index       : 1
    ---------------------------------------------------------
       Lock          : Enabled
       Loopback      : Disabled
```

P1

```
#sh mpls-tp tunnel tnl_co
 Tunnel-id             : 1              Tunnel-Name         : tnl_co
 Source ICC-Oper-ID    : INAIRTEL       Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL       Destination Node-Id : 4.4.4.4
 Role  : Transit                        Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)        Tunnel State        : UP


    Forward-Path : ILM   <OPCODE : Swap>
      Incoming-Label : 3001             Incoming-Interface  : eth2
      ILM-Index      : 1                Cross-Connect-Index : 1
      Outgoing-Label : 3002             Outgoing-Interface  : eth3
      NHLFE Index    : 1
      BW-class       : N/A
      Status : UP
    Reverse-Path : ILM   <OPCODE : Swap>
      Incoming-Label : 4001             Incoming-Interface  : eth3
      ILM-Index      : 2                Cross-Connect-Index : 2
      Outgoing-Label : 4002             Outgoing-Interface  : eth2
      NHLFE Index    : 2
      BW-class       : N/A
      Status : UP
    ---------------------------------------------------------
     MEG Index       : 1             ME Index       : 2
    ---------------------------------------------------------
       Lock          : Disabled
       Loopback      : Disabled
```

P2

```
#sh mpls-tp tunnel tnl_co
 Tunnel-id             : 1              Tunnel-Name         : tnl_co
 Source ICC-Oper-ID    : INAIRTEL       Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL       Destination Node-Id : 4.4.4.4
 Role  : Transit                        Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)        Tunnel State        : UP


    Forward-Path : ILM   <OPCODE : Swap>
      Incoming-Label : 3002             Incoming-Interface  : eth2
      ILM-Index      : 3                Cross-Connect-Index : 1
      Outgoing-Label : 3003             Outgoing-Interface  : eth3
      NHLFE Index    : 1
      BW-class       : N/A
```

```
          Status : UP
        Reverse-Path : ILM   <OPCODE : Swap>
          Incoming-Label : 4000               Incoming-Interface  : eth3
          ILM-Index      : 4                  Cross-Connect-Index : 2
          Outgoing-Label : 4001               Outgoing-Interface  : eth2
          NHLFE Index    : 2
          BW-class       : N/A
          Status : UP
        ---------------------------------------------------------
         MEG Index       : 1              ME Index        : 3
        ---------------------------------------------------------
           Lock          : Disabled
           Loopback      : Disabled
```

PE2

```
    #sh mpls-tp tunnel tnl_co
     Tunnel-id             : 1               Tunnel-Name          : tnl_co
     Source ICC-Oper-ID    : INAIRTEL        Source Node-Id       : 1.1.1.1
     Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
     Role  : Destination                     Tunnel Index         : 1
     Mode  : COROUTED(bidirectional)         Tunnel State         : UP


        Forward-Path : ILM   <OPCODE : Pop>
          Incoming-Label : 3003               Incoming-Interface  : eth2
          ILM-Index      : 1                  Cross-Connect-Index : 1
          Status : UP
        Reverse-Path : NHLFE   <OPCODE : Push>
          Outgoing-Label : 4000               Outgoing-Interface : eth2
          NHLFE Index    : 2
          BW-class       : N/A
          Status : UP
        ---------------------------------------------------------
         MEG Index       : 1              ME Index        : 4
        ---------------------------------------------------------
           Lock          : Disabled
           Loopback      : Disabled
```

Associated Bi-Directional Tunnel

Forward Tunnel

PE1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 1.1.1.1`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as provider and set the local identifier to 10.1.1.1
`(config)#mpls-tp tunnel 2 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.

(config-tnl)#tunnel-name tnl_as_fwd	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#nhlfe-entry 1001 eth1	Configure the NHFE entry to push the label at ingress for the forward path.

P1 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp itut cc IN icc AIRTEL node-id 2.2.2.2	Configure the country code, carrier code, and node identifier.
(config)#interface eth2	Enter interface mode for eth2
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure the interface as provider and set the local identifier to 20.1.1.1
(config)#interface eth3	Enter interface mode for eth3
(config-if)#mpls-tp provider-interface 30.1.1.1	Configure the interface as provider and set the local identifier to 30.1.1.1
(config)#mpls-tp tunnel 2 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
(config-tnl)#tunnel-name tnl_as_fwd	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#ilm-entry 1001 eth2 swap 1002 eth3	Configure the ILM entry to swap the label at transit for the forward path.

P2 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp itut cc IN icc AIRTEL node-id 3.3.3.3	Configure the country code, carrier code, and node identifier.
(config)#interface eth2	Enter interface mode for eth2
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure the interface as provider and set the local identifier to 20.1.1.1
(config)#interface eth3	Enter interface mode for eth3
(config-if)#mpls-tp provider-interface 30.1.1.1	Configure the interface as provider and set the local identifier to 30.1.1.1
(config)#mpls-tp tunnel 2 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
(config-tnl)#tunnel-name tnl_as_fwd	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#ilm-entry 1002 eth2 swap 1003 eth3	Configure the ILM entry to swap the label at transit for the forward path.

PE2 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp itut cc IN icc AIRTEL node-id 4.4.4.4	Configure the country code, carrier code, and node identifier.
(config)#interface eth1	Enter interface mode for eth1
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure the interface as provider and set the local identifier to 10.1.1.1
(config)#mpls-tp tunnel 2 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
(config-tnl)#tunnel-name tnl_as_fwd	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#ilm-entry 1003 eth2 pop	Configure the ILM entry to pop the label for the forward path at egress.

Reverse Tunnel

PE2 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp itut cc IN icc AIRTEL node-id 4.4.4.4	Configure the country code, carrier code, and node identifier.
(config)#interface eth4	Enter interface mode for eth4
(config-if)#mpls-tp provider-interface 40.1.1.1	Configure the interface as provider and set the local identifier to 40.1.1.1
(config)#mpls-tp tunnel 3 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
(config-tnl)#tunnel-name tnl_as_rev	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#nhlfe-entry 2002 eth4	Configure the NHFE entry to push the label for the reverse path.

P1 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp itut cc IN icc AIRTEL node-id 2.2.2.2	Configure the country code, carrier code, and node identifier.
(config)#interface eth1	Enter interface mode for eth1
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure the interface as provider and set the local identifier to 10.1.1.1
(config)#interface eth4	Enter interface mode for eth4
(config-if)#mpls-tp provider-interface 40.1.1.1	Configure the interface as provider and set the local identifier to 40.1.1.1

`(config)#mpls-tp tunnel 3 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name tnl_as_rev`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 2003 eth4 swap 2004 eth1`	Configure the ILM entry to SWAP the labels at transit for the forward path

P2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 3.3.3.3`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as provider and set the local identifier to 10.1.1.1
`(config)#interface eth4`	Enter interface mode for eth3
`(config-if)#mpls-tp provider-interface 40.1.1.1`	Configure the interface as provider and set the local identifier to 40.1.1.1
`(config)#mpls-tp tunnel 3 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name tnl_as_rev`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 2002 eth4 swap 2003 eth1`	Configure the ILM entry to swap the label at transit for the forward path

PE1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 1.1.1.1`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth2`	Enter interface mode for eth2
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 20.1.1.1
`(config)#mpls-tp tunnel 3 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name tnl_as_rev`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 2004 eth2 pop`	Configure the ILM entry to pop the label at egress for the reverse path

Associate Forward and Reverse Tunnel

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp associate fwd-tunnel tnl_as_fwd rev-tunnel tnl_as_rev`	Associate the forward and reverse tunnels.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp associate fwd-tunnel tnl_as_rev rev-tunnel tnl_as_fwd`	Associate the forward and reverse tunnels.

Validation: Forward Tunnel

PE1

```
#sh mpls-tp tunnel tnl_as_fwd
 Tunnel-id              : 2                 Tunnel-Name          : tnl_as_fwd
 Source ICC-Oper-ID     : INAIRTEL          Source Node-Id       : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL           Destination Node-Id : 4.4.4.4
 Role   : Source                            Tunnel Index         : 2
 Mode   : ASSOCIATED(unidirectional)        Tunnel State         : UP
 Associated-Tunnel    : tnl_as_rev

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001                 Outgoing-Interface : eth1
       NHLFE Index    : 3
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 2              ME Index        : 11
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
```

P1

```
#sh mpls-tp tunnel tnl_as_fwd
 Tunnel-id              : 2                 Tunnel-Name          : tnl_as_fwd
 Source ICC-Oper-ID     : INAIRTEL          Source Node-Id       : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL           Destination Node-Id : 4.4.4.4
 Role   : Transit                           Tunnel Index         : 2
 Mode   : ASSOCIATED(unidirectional)        Tunnel State         : UP
 Associated-Tunnel    : tnl_as_rev

     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1001                 Incoming-Interface  : eth2
       ILM-Index      : 3                    Cross-Connect-Index : 3
       Outgoing-Label : 1002                 Outgoing-Interface  : eth3
       NHLFE Index    : 3
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
```

```
 MEG Index       : 2              ME Index       : 22
---------------------------------------------------------
   Lock          : Disabled
   Loopback      : Disabled
```

P2

```
#sh mpls-tp tunnel tnl_as_fwd
 Tunnel-id              : 2                Tunnel-Name          : tnl_as_fwd
 Source ICC-Oper-ID     : INAIRTEL         Source Node-Id       : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL          Destination Node-Id : 4.4.4.4
 Role  : Transit                           Tunnel Index         : 2
 Mode  : ASSOCIATED(unidirectional)        Tunnel State         : UP
 Associated-Tunnel   : tnl_as_rev

     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1002                Incoming-Interface  : eth2
       ILM-Index      : 6                   Cross-Connect-Index : 3
       Outgoing-Label : 1003                Outgoing-Interface  : eth3
       NHLFE Index    : 3
       BW-class       : N/A
       Status : UP
---------------------------------------------------------
 MEG Index       : 2              ME Index       : 33
---------------------------------------------------------
   Lock          : Disabled
   Loopback      : Disabled
```

PE2

```
#sh mpls-tp tunnel tnl_as_fwd
 Tunnel-id              : 2                Tunnel-Name          : tnl_as_fwd
 Source ICC-Oper-ID     : INAIRTEL         Source Node-Id       : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL          Destination Node-Id : 4.4.4.4
 Role  : Destination                       Tunnel Index         : 2
 Mode  : ASSOCIATED(unidirectional)        Tunnel State         : UP
 Associated-Tunnel   : tnl_as_rev

     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1003                Incoming-Interface  : eth2
       ILM-Index      : 2                   Cross-Connect-Index : 3
       Status : UP
---------------------------------------------------------
 MEG Index       : 3              ME Index       : 444
---------------------------------------------------------
   Lock          : Disabled
   Loopback      : Disabled
```

Validation: Reverse Tunnel

PE1

```
#sh mpls-tp tunnel tnl_as_rev
 Tunnel-id              : 3                Tunnel-Name          : tnl_as_rev
 Source ICC-Oper-ID     : INAIRTEL         Source Node-Id       : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL          Destination Node-Id : 1.1.1.1
 Role  : Destination                       Tunnel Index         : 3
 Mode  : ASSOCIATED(unidirectional)        Tunnel State         : UP
 Associated-Tunnel   : tnl_as_fwd
```

```
    Reverse-Path : ILM   <OPCODE : Pop>
      Incoming-Label : 2004              Incoming-Interface  : eth2
      ILM-Index      : 2                 Cross-Connect-Index : 4
      Status : UP
MEG Index       : 2             ME Index        : 11
    ---------------------------------------------------------
       Lock           : Disabled
       Loopback       : Disabled
```

P1

```
#sh mpls-tp tunnel tnl_as_rev
 Tunnel-id             : 3                 Tunnel-Name          : tnl_as_rev
 Source ICC-Oper-ID    : INAIRTEL          Source Node-Id       : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL          Destination Node-Id : 1.1.1.1
 Role  : Transit                           Tunnel Index         : 3
 Mode  : ASSOCIATED(unidirectional)        Tunnel State         : UP
 Associated-Tunnel   : tnl_as_fwd

     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 2003              Incoming-Interface  : eth4
       ILM-Index      : 4                 Cross-Connect-Index : 4
       Outgoing-Label : 2004              Outgoing-Interface  : eth1
       NHLFE Index    : 4
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 3             ME Index        : 222
     ---------------------------------------------------------
        Lock           : Disabled
        Loopback       : Disabled
```

P2

```
#sh mpls-tp tunnel tnl_as_rev
 Tunnel-id             : 3                 Tunnel-Name          : tnl_as_rev
 Source ICC-Oper-ID    : INAIRTEL          Source Node-Id       : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL          Destination Node-Id : 1.1.1.1
 Role  : Transit                           Tunnel Index         : 3
 Mode  : ASSOCIATED(unidirectional)        Tunnel State         : UP
 Associated-Tunnel   : tnl_as_fwd

     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 2002              Incoming-Interface  : eth4
       ILM-Index      : 7                 Cross-Connect-Index : 4
       Outgoing-Label : 2003              Outgoing-Interface  : eth1
       NHLFE Index    : 4
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 3             ME Index        : 333
     ---------------------------------------------------------
        Lock           : Disabled
        Loopback       : Disabled
```

PE2

```
#sh mpls-tp tunnel tnl_as_rev
```



```
Tunnel-id              : 3              Tunnel-Name         : tnl_as_rev
Source ICC-Oper-ID     : INAIRTEL       Source Node-Id      : 4.4.4.4
Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 1.1.1.1
Role  : Source                          Tunnel Index        : 3
Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
Associated-Tunnel   : tnl_as_fwd

    Forward-Path : NHLFE   <OPCODE : Push>
      Outgoing-Label : 2002              Outgoing-Interface : eth4
      NHLFE Index    : 4
      BW-class       : N/A
      Status : UP
    ---------------------------------------------------------
     MEG Index       : 2             ME Index        : 44
    ---------------------------------------------------------
       Lock          : Disabled
       Loopback      : Disabled
```

CHAPTER 22 MPLS-TP Tunnel Bandwidth

Quality of service (QoS) is the ability to assign different priorities to different applications, users or data flows, or to guarantee a certain level of performance to a data flow. Bandwidth is a factor of QoS. This chapter describes configuring and then validating the bandwidth of a bidirectional tunnel.

For information about connectivity, refer to Figure 20-2 on page 272.

For details about configuring a bidirectional tunnel, refer to Co-Routed Bi-Directional Tunnel on page 277

Configure Tunnel Bandwidth

Following is a summary of configuring tunnel bandwidth.

1. Define the class type names, and enable the class types. For example:
   ```
   mpls class-type ct0 class0
   ```
2. Configure the TE class type name and the pre-emption priority for each TE class. For example:
   ```
   mpls te-class te0 class0 0
   ```
3. Configure bandwidth class name that defines bandwidth; define the priority for the class type. For example:
   ```
   mpls bandwidth-class bw_1
   bandwidth 1000 setup-priority 0 class-type class0
   exit
   ```
4. Enable MPLS-TP on the interface, eth1, set the corresponding IP address on the interface, reserve the bandwidth, and configure the bandwidth constraint for each class type on the eth1 interface.
   ```
   interface eth1
   mpls-tp provider-interface 10.1.1.1
   Reservable-bandwidth 40000
   bandwidth-constraint class0 1000 exit
   ```

Note: For information about the commands used in the first three steps of the summary (bandwidth name, class and band), refer to the NSM CR.

Detailed configuration examples are provided below. For a view of tunnel connectivity, refer to Figure 20-2 on page 272.

PE1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 100 node-id 1.1.1.1`	Configure global ID as 100 and node ID as 1.1.1.1 for a PE1 node.
`(config)#mpls class-type ct0 class0`	Define a class-type name and enable class-type.
`(config)#mpls te-class te0 class0 0`	Configure the TE class type name and the pre-emption priority for each TE class.
`(config)#mpls bandwidth-class bw_1`	Configure the bandwidth class with a bandwidth-class name,

(config-mpls-bw)#bandwidth 1000 setup-priority 0 class-type class0	Define the bandwidth value as 1000; set up the priority for specified class as 0.
(config)#exit	Exit the Bandwidth Class command mode,
(config)#interface eth1	Enter interface mode.
(config-if)#reservable-bandwidth 10000	Provide bandwidth reserve for the interface. The bandwidth value range 1–10000000000.
(config-if)#bandwidth-constraint class0 1000	Define value for bandwidth constraint. The bandwidth value range is 1–10000000000.
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure the interface eth2 as the provider interface and the local interface ID as 10.1.1.1,
(config-if)#exit	Exit the Interface command mode.
(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3	Configure the tunnel: tunnel ID 1; origination from PE1 node (global ID 100 and node ID 1.1.1.1); destination to PE2 node (global ID 300 and node ID 3.3.3.3).
(config-tnl)#tunnel-name tnl1	Configure the tunnel name: tnl1,
(config-tnl)#tunnel-mode bidirectional	Configure the tunnel mode as bidirectional.
(config-bidir-tnl)#forward-path nhlfe-entry 1001 eth1 bw-class bw_1	Configure the NHFLE entry label: push the label at ingress for the forward path. In this example, 1001 is the label and bw_1 is the bandwidth associated with the tunnel,
(config-bidir-tnl)#reverse-path ilm-entry 2002 eth1 pop	Configure the ILM entry label: pop at ingress for the reverse path.

P1 (NSM)

#configure terminal	Enter the Configure the mode.
(config)#mpls-tp global-id 200 node-id 2.2.2.2	Configure the global ID and node ID at Transit node (P1).
(config)#mpls class-type ct0 class0	Define the class-type name and enable class-type.
(config)#mpls te-class te0 class0 0	Define class-type name and pre-emption priority for the TE-class.
(config)#mpls bandwidth-class bw_1	Configure bandwidth class with bandwidth-class name.
(config-mpls-bw)#bandwidth 1000 setup-priority 0 class-type class0	Define the bandwidth value (1–10000000000 bits); set up the priority (0–7) for specific class.
(config-mpls-bw)#exit	Exit the Bandwidth command mode.
(config)#interface eth1	Enter interface mode.
(config-if)#mpls-tp provider-interface 10.1.1.2	Configure eth1 as the provider interface and the local interface ID as 10.1.1.2.
(config-if)#reservable-bandwidth 10000	Provide the reserve bandwidth for the interface. The bandwidth range: 1–10000000000 bits.
(config-if)#bandwidth-constraint class0 1000	Define the bandwidth constraint. The bandwidth range: 1-10000000000 bits.
(config-if)#exit	Exit the Interface mode.
(config)#interface eth2	Enter interface mode.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure eth2 as the provider interface and the local interface ID as 20.1.1.1.
(config-if)#reservable-bandwidth 10000	Provide reserve bandwidth for specific interface. The bandwidth range is 1–10000000000 bits.

`(config-if)#bandwidth-constraint class0 1000`	Define the bandwidth constraint for class-type. The bandwidth range is 1–10000000000 bits.
`(config-if)#exit`	Exit Interface command mode.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel: tunnel ID 1; origination from the PE1node (global ID 100 and node ID 1.1.1.1); destination at PE2 node (global ID 300 and node ID 3.3.3.3).
`(config-tnl)#tunnel-name tnl1`	Configure the tunnel name as tnl1.
`(config-tnl)#tunnel-mode bidirectional`	Configure the tunnel mode as bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 1001 eth1 swap 1002 eth2 bw-class bw_1`	Configure the ILM entry label: swap the labels at transit for the forward path.In this example, 1001 and 1002 are the MPLS-TP label; bw_1 is the bandwidth associated with tunnel
`(config-bidir-tnl)#reverse-path ilm-entry 2001 eth2 swap 2002 eth1 bw-class bw_1`	Configure the ILM entry label: swap the labels at transit for the reverse path. In this example, 2001 and 2002 are the MPLS-TP label; bw_1 is the bandwidth associated with tunnel

PE2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 300 node-id 3.3.3.3`	Configure global ID and node ID to a particular node.
`(config)#mpls class-type ct0 class0`	Define the class-type name and enable class-type.
`(config)#mpls te-class te0 class0 0`	Define class-type name and pre-emption priority for the TE-class.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 20.1.1.2`	Configure the interface eth3 as the provider interface and the local interface ID as 20.1.1.2.
`(config-if)#reservable-bandwidth 10000`	Provide reserve bandwidth for the interface.The bandwidth range is 1–10000000000 bits.
`(config-if)#bandwidth-constraint class0 1000`	Define the bandwidth constraint for class-type. The bandwidth range is1–10000000000 bits.
`(config-if)#exit`	Exit the Interface mode from eth2.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel: tunnel ID 1; origination from PE1 node (global ID 100 and node ID 1.1.1.1); destination to PE2 node (global ID 300 and node ID 3.3.3.3).
`(config-tnl)#tunnel-name tnl1`	Configure the tunnel name: tnl1.
`(config-tnl)#tunnel-mode bidirectional`	Configure the tunnel mode as bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 1002 eth2 pop`	Configure ILM entry label: pop the label for forward path at egress.Here 1002 is the mpls-tp label.
`(config-bidir-tnl)#reverse-path nhlfe-entry 2001 eth2 bw-class bw_1`	Configure the NHLF entry label: push for reverse path at egress. In this example, 2001 is the label value and bw_1 is the bandwidth associated with the tunnel.

Validation

PE1, PE2, and P1

```
#show mpls bandwidth-class
Bandwidth-class : bw_1
Bandwidth : 1k Setup-priority : 0 Class-type : class0
```

PE1

```
PE1#show mpls-tp tunnel

<================================================================================>
 tunnel-id              : 1               tunnel-Name         : tnl1
 Source Global-Id       : 100            Source Node-Id      : 1.1.1.1
 Destination Global-Id : 300             Destination Node-Id : 3.3.3.3
 Role   : Source                          tunnel Index        : 1
 Mode   : COROUTED
 State : UP
  --------------------------------------------------------
   LSP : 1       Type : Primary       Bidirectional : Yes
  --------------------------------------------------------
     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001                Outgoing-Interface : eth1
       NHLFE Index    : 1
              BW-class       : bw_1               Qos Id : 2    BW : 1k
       Status : UP

     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2002                Incoming-Interface  : eth1
       ILM-Index      : 1                  Cross-Connect-Index : 2
       Status : UP
```

P1

```
P1#show mpls-tp tunnel

<================================================================================>
 tunnel-id              : 1              tunnel-Name         : tnl1
 Source Global-Id       : 100            Source Node-Id      : 1.1.1.1
 Destination Global-Id : 300             Destination Node-Id : 3.3.3.3
 Role   : Transit                         tunnel Index        : 1
 Mode   : COROUTED
 State : UP
  --------------------------------------------------------
   LSP : 1      Type : Primary       Bidirectional : Yes
  --------------------------------------------------------
     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1001                Incoming-Interface  : eth1
       ILM-Index      : 1                  Cross-Connect-Index : 1
       Outgoing-Label : 1002                Outgoing-Interface  : eth2
       NHLFE Index    : 1
                     BW-class       : bw_1               Qos Id : 2    BW : 1k
       Status : UP


     Reverse-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 2001                Incoming-Interface  : eth2
```

```
        ILM-Index      : 2                Cross-Connect-Index : 2
        Outgoing-Label : 2002              Outgoing-Interface  : eth1
        NHLFE Index    : 2
                      BW-class       : bw_1              Qos Id : 2    BW : 1k
        Status : UP
```

PE2

```
PE2#show mpls-tp tunnel

<==============================================================================>
 tunnel-id              : 1                 tunnel-Name         : tnl1
 Source Global-Id       : 100              Source Node-Id      : 1.1.1.1
 Destination Global-Id  : 300              Destination Node-Id : 3.3.3.3
 Role  : Destination                        tunnel Index        : 1
 Mode  : COROUTED
 State : UP
  --------------------------------------------------------
   LSP : 1       Type : Primary       Bidirectional : Yes
  --------------------------------------------------------
     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1002               Incoming-Interface  : eth2
       ILM-Index      : 1                 Cross-Connect-Index : 1
       Status : UP

     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2001              Outgoing-Interface : eth2
       NHLFE Index    : 2
              BW-class       : bw_1              Qos Id : 2    BW : 1k
       Status : UP
```

CHAPTER 23 MPLS-TP IPv4 Map Route

IPv4 traffic mapping to an MPLS-TP tunnel is achieved by mapping a destination IP Prefix (with a mask) to a MPLS-TP tunnel (identified by tunnel name) statically. IPv4 prefixes can be mapped to the following tunnels:

- Unidirectional tunnel on Ingress node only,
- Associated tunnel designated as Forward-tunnel on ingress node only.

  Note: IPv4 traffic can also be mapped to the reverse tunnel at the egress (which would be the ingress node for the reverse tunnel).
- bidirectional tunnel on ingress and egress nodes only.

Topology

Figure 23-1 shows an example of a route. Add the static route at CE1 (customer edge router 1) node to reach the PE2 (provider edge router 2) network. Similarly, add the static route at CE2 node to reach the PE1 node. Following is a summary of the configuration:

- Configure the static route on CE1.
- Map the IPv4 route at PE1 and PE2 (if the tunnel is co-routed).
- Ping traffic to go through CE1 to CE2.

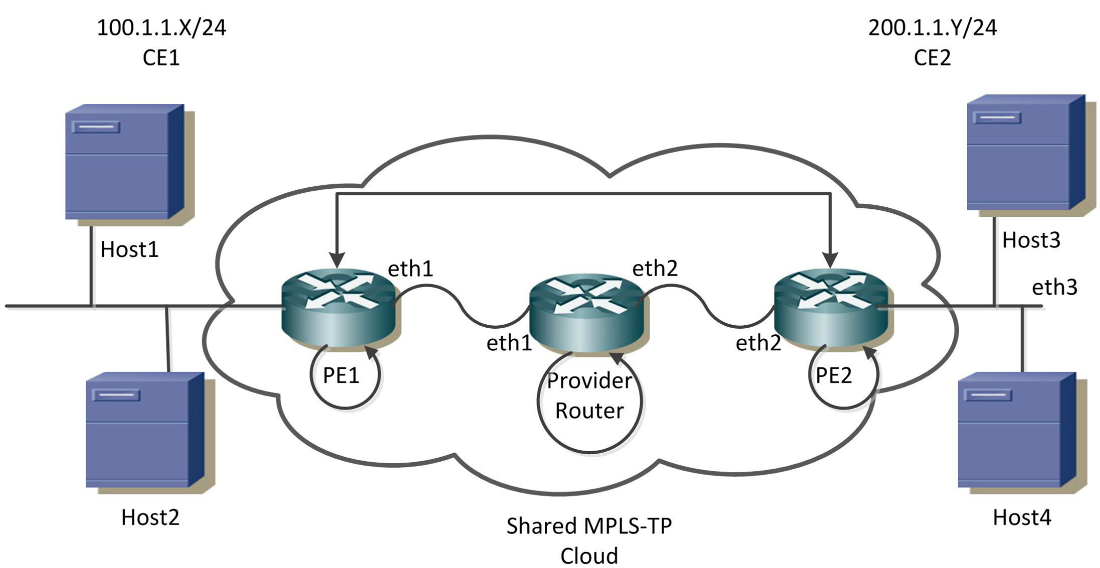


Figure 23-1: IPv4 Map Route

The configurations are based on the network shown in Figure 23-1.

- For tunnel connectivity, refer to Figure 20-2 on page 272.
- For details about configuring a co-routed tunnel, refer to Co-Routed Bi-Directional Tunnel on page 277.

Configure Static Route on CE1 and CE2

CE1 (NSM)

`#configure terminal`	Enter configure mode
`(config)#ip route 200.1.1.0/24 100.1.1.2`	Configure the static route for the destination network, set the next hop at the connected PE1 interface.

CE2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#ip route 100.1.1.0/24 200.1.1.2`	Configure the static route for the destination network, set the next hop at the connected PE1 interface.

Map IPv4 Route at PE1 and PE2—Co-Routed Tunnel

Note: This example applies only for co-routed tunnels.

PE1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls map-route 200.1.1.0/24 tp-tunnel tn1`	Map IPv4 traffic based on the destination address of an IP Packet to a MPLS-TP tunnel.

PE2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls map-route 100.1.1.0/24 tp-tunnel tn2`	Configure the IPv4 traffic map based on the destination address of an IP packet to a MPLS-TP tunnel.

Validation

Ping from CE1 to reach the CE2 network. The ping should go through the MPLS-TP tunnel to reach the CE2 network.

PE1

```
#show mpls mapped-routes
Mapped-route        IPv4 FEC            MPLS-TP tunnel
200.1.1.0/24     N/A                 tnl1
```

PE2

```
#show mpls mapped-routes
Mapped-route        IPv4 FEC            MPLS-TP tunnel
```


CHAPTER 24 MPLS-TP Layer 2 Virtual Circuit

The MPLS-TP Layer 2 Virtual Circuit (VC) is a point-to-point Layer-2 connection that is transported by a Multi-Protocol Label Switching Transport Profile (MPLS-TP) 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.

Topology

The diagram below illustrates the configuration example in this chapter. Interfaces eth2 on PE1 and eth3 on PE2 are connected to the customer network (Host3 and Host 4). Interfaces eth1 on PE1 and eth2 on PE2 are connected to the MPLS-TP cloud. The following is a summary of the VC configuration process:

- Configure the VC
- Bind the customer interface to the VC
- Map the VC to the tunnel

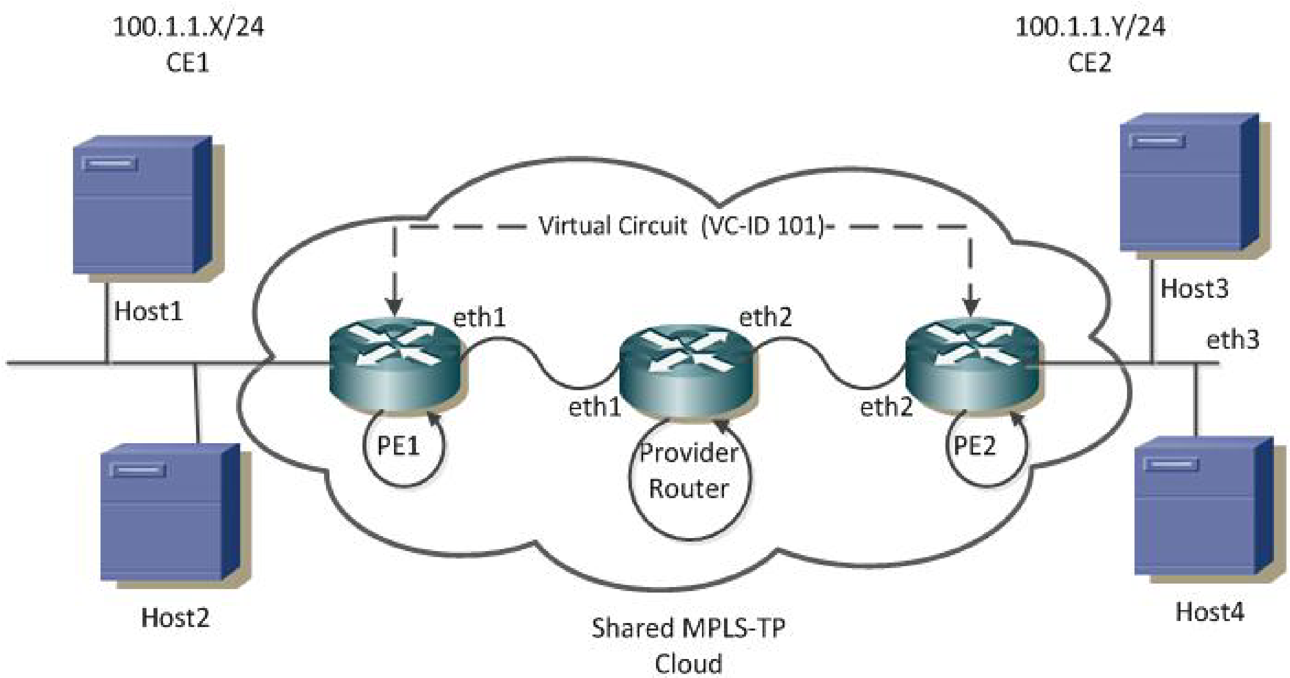


Figure 24-1: Layer 2 Virtual Circuit

The configurations are based on the network shown in Figure 24-1.

- For tunnel connectivity, refer to Figure 21-1.
- For details about configuring a co-routed tunnel, refer to Co-Routed Bi-Directional Tunnel on page 277.

Configure Virtual Circuit

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.

PE1 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit VC-1 101 300 3.3.3.3 200 grp-1 manual	Configure the virtual circuit (VC) for PE2. In this example, VC-1 is the VC name, 101 is the VC ID, 300 is the peer global ID, 3.3.3.3 is the VC endpoint node ID, 200 is VC endpoint, AC-ID grp-1 is the group name.

PE2 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit VC-1 101 100 1.1.1.1 200 grp-1 manual	Configure the virtual circuit (VC) for PE1. In this example, VC-1 is the VC name, 101 is the VC ID, 100 is the peer global ID, 1.1.1.1 is the VC endpoint node ID, 200 is VC endpoint, VC is VC-ID, grp-1 is the group name.

Bind Customer Interface to VC

Attach the Customer Interface to the VC.

Note: Layer 2 VCs can only be bound to Layer 2 interfaces. VC encapsulation should be Ethernet (default), VLAN, HDLC or PPP.

Layer-2 Untagged Traffic

Use Access mode for Layer 2 untagged traffic.

PE1 (NSM)

#configure terminal	Enter configure mode.
(config)#bridge 1 protocol ieee vlan- bridge	Configure the VLAN for bridge 1.
(config)#interface eth2	Enter interface mode.
(config-if)#switchport	Switch to Layer 2 mode.
(config-if)#bridge-group 1	Associate the eth2 interface with bridge group 1.
(config-if)#switchport mode access	Set the switching characteristics of this interface to access mode.
(config-if)#mpls-tp service-interface type layer-2 200	Configure the service interface.in this example, local AC-ID is 200.
(config-if)#mpls-l2-circuit VC-1 ethernet	Bind the access interface to the Ethernet VC.

PE2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#bridge 1 protocol ieee vlan- bridge`	Specify the VLAN for bridge 1.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer 2 mode.
`(config-if)#bridge-group 1`	Associate the eth3 interface with bridge group 1.
`(config-if)#switchport mode access`	Set the switching characteristics of this interface to Access mode.
`(config-if)#mpls-tp service-interface type layer-2 200`	Configure the service interface.In this example, local AC-ID is 200.
`(config-if)#mpls-l2-circuit VC-1 ethernet`	Bind the interface to the VC.

Layer-2 Tagged Traffic

Use Trunk mode for Layer 2 tagged traffic. The following configuration allows only VLAN 2 and 3 traffic.

PE1

`#configure terminal`	Enter configure mode.
`(config)#bridge 1 protocol ieee vlan- bridge`	Specify the VLAN for bridge 1.
`(config)#mpls l2-circuit VC-2 201 300 3.3.3.3 200 grp-1 manual`	Configure the VC for PE2. In this example, VC-2 is the VC name, 201 is the VC ID, 300 is the peer global ID, 3.3.3.3 is the VC endpoint node ID, 200 is VC endpoint VC-ID and grp-1 is the group name.
`(config)#vlan database`	Enter the VLAN configuration mode.
`(config-vlan)#vlan 2 bridge 1`	Enable the state of VLAN 2 on bridge 1.
`(config-vlan)#exit`	Exit the VLAN configuration mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer 2 mode.
`(config-if)#bridge-group 1`	Associate the eth2 interface with bridge group 1.
`(config-if)#switchport mode trunk`	Configure the switching characteristics of this interface to Trunk mode.
`(config-if)#switchport trunk allowed vlan add 2`	Enable VLAN ID 2 on this port.
`(config-if)#mpls-tp service-interface type layer-2 200`	Configure the service interface.in this example local AC-id is 200.
`(config-if)#mpls-l2-circuit VC-2 vlan 2`	Allow VLAN 2 traffic on this VC.

PE2

`#configure terminal`	Enter configure mode.
`(config)#bridge 1 protocol ieee vlan- bridge`	Specify the VLAN for bridge 1.
`(config)#mpls l2-circuit VC-2 201 100 1.1.1.1 200 grp-1 manual`	Configure the VC for PE2. In this example, VC-2 is the VC name, 201 is the VC ID and 1.1.1.1 is the VC endpoint node-id.

`(config)#interface eth3`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer 2 mode.
`(config-if)#bridge-group 1`	Associate the eth1 interface with bridge group 1.
`(config-if)#switchport mode trunk`	Configure the switching characteristics of this interface to Trunk mode.
`(config-if)#switchport trunk allowed vlan add 2`	Enable VLAN ID 2 on this port.
`(config-if)#mpls-tp service-interface type layer-2 200`	Configure the service interface.in this example local AC-id is 200.
`(config-if)#mpls-l2-circuit VC-2 vlan 2`	Allow VLAN 2 traffic on this VC.

Map VC to Tunnel

PE1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit-fib-entry 101 1111 2222 tp-tunnel tnl1 eth2`	Configured an FIB entry. In this example, 111 is the incoming label, 2222 is the outgoing label, 3.3.3.3 is the endpoint, eth2 is the AC interface name, and tnl1 is the tunnel name.

PE2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit-fib-entry 101 2222 1111 tp-tunnel tnl2 eth3`	Configure an FIB entry. In this example, 2222 is the incoming label, 1111 is the outgoing label, 3.3.3.3 is the endpoint, eth3 is the AC interface name, and tnl2 is the tunnel name.

Validation

For a correct configuration, the following commands should provide these results:

- Status is `Active` in the `show mpls vc-table` command on ingress/egress for the configured virtual circuit
- Ping from CE1 to CE2 is successful

Validation is displayed in the following example. The command used to display Layer 2 virtual circuit information:

- show mpls mapped-routes (in the NSM daemon)

```
#show mpls vc-table
VC-ID  Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf  Out Label tunnel-Label Nexthop
Status
100    2       N/A           eth1  eth2       1111  2001       N/A      Active
```


CHAPTER 25 MPLS-TP MEG Configuration

This chapter contains configuration examples for MPLS-TP Maintenance Entity Groups (MEGs).

Configuring MEGs Using IETF Identifiers

Refer to Figure 21-1 on page 275 for the topology.

Tunnel Service

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-1`	Configure the MEG name as meg-1.
`(config-ietf-meg)#service type tunnel`	Configure the service type as tunnel.
`(config-ietf-meg)#me me-1 tunnel`	Configure the ME name as me-1.
`(config-ietf-me)#service tunnel tnl1`	Associate tnl1 with the ME.

P1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-1`	Configure the MEG name as meg-1.
`(config-ietf-meg)#service type tunnel`	Configure the service type as tunnel.
`(config-ietf-meg)#me me-1 tunnel`	Configure the ME name as me-1.
`(config-ietf-me)#service tunnel tnl1`	Associate tnl1 with the ME.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-1`	Configure the MEG name as meg-1.
`(config-ietf-meg)#service type tunnel`	Configure the service type as tunnel.
`(config-ietf-meg)#me me-1 tunnel`	Configure the ME name as me-1.
`(config-ietf-me)#service tunnel tnl1`	Associate tnl1 with the ME.

Validation

PE1

```
PE1#show ietf meg brief

Total Number of MEGs configured : 1
============================================================================
```

```
Maintenance Entity Group  : meg-1              MEG Index    : 1
Service Type              : Tunnel             MP Location  : Per-node
-------------------------------------------------------------------------------
   Maintenance Entity     : me-1               ME Index     : 1
   Tunnel Name            : tnl1               MP Type      : MEP
   Oper Status            : UP
------------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled


PE1#show ietf meg summary

Total Number of MEGs configured : 1
-------------------------------------------------------------------------------
MEG-Name            Service-Type    ME-Name             MP Type    Oper
Status
-------------------------------------------------------------------------------
meg-1               Tunnel          me-1                MEP        UP
```

P1

```
P1#show ietf meg brief

Total Number of MEGs configured : 1
=============================================================================
Maintenance Entity Group  : meg-1              MEG Index    : 1
Service Type              : Tunnel             MP Location  : Per-node
-------------------------------------------------------------------------------
   Maintenance Entity     : me-1               ME Index     : 1
   Tunnel Name            : tnl1               MP Type      : MIP
   Oper Status            : UP
------------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled


P1#show ietf meg summary

Total Number of MEGs configured : 1
------------------------------------------------------------------------------
MEG-Name            Service-Type    ME-Name             MP Type    Oper
Status
-------------------------------------------------------------------------------
meg-1               Tunnel          me-1                MIP        UP
```

P2

```
PE2#show ietf meg brief

Total Number of MEGs configured : 1
```

```
==========================================================================
Maintenance Entity Group   : meg-1             MEG Index    : 1
Service Type               : Tunnel            MP Location  : Per-node
---------------------------------------------------------------------------
   Maintenance Entity      : me-1              ME Index     : 1
   Tunnel Name             : tnl1              MP Type      : MEP
   Oper Status             : UP
--------------------------------------------------------------------------
      CC-CV                : Disabled
      Loopback             : Disabled
      Lock                 : Disabled
      Fault-Management     : Disabled
      Loss-Measurement     : Disabled
      Delay-Measurement    : Disabled


PE2#show ietf meg summary

Total Number of MEGs configured : 1
---------------------------------------------------------------------------
MEG-Name             Service-Type    ME-Name             MP Type    Oper
Status
---------------------------------------------------------------------------
meg-1                Tunnel          me-1                MEP        UP
```

Virtual Circuit Service

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-10`	Configure the MEG name as meg-10
`(config-ietf-meg)#service type vc`	Configure the service type as virtual circuit.
`(config-ietf-meg)#me me-10 vc`	Configure the ME name as me-10
`(config-ietf-me)#service vc 101`	Associate virtual circuit 101 with the ME.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-1`	Configure the MEG name as meg-1.
`(config-ietf-meg)#service type vc`	Configure the service type as virtual circuit.
`(config-ietf-meg)#me me-1 vc`	Configure the ME name as me-1.
`(config-ietf-me)#service vc 101`	Associate virtual circuit 101 with the ME.

Validation

PE1

```
PE1#show ietf meg brief

Total Number of MEGs configured : 1
==========================================================================
```

```
Maintenance Entity Group  : meg-10              MEG Index    : 1
Service Type              : VC             MP Location  : Per-node
-------------------------------------------------------------------------------
   Maintenance Entity     : me-10               ME Index     : 1
   Tunnel Name            : 101              MP Type      : MEP
   Oper Status            : UP
------------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled
```

PE2

```
PE2#show ietf meg summary

Total Number of MEGs configured : 1
-------------------------------------------------------------------------------
MEG-Name             Service-Type    ME-Name              MP Type    Oper
Status
-------------------------------------------------------------------------------
meg-10                VC          me-10                MEP        UP


PE2#show ietf meg brief

Total Number of MEGs configured : 1
=============================================================================
Maintenance Entity Group  : meg-10              MEG Index    : 1
Service Type              : VC            MP Location  : Per-node
-------------------------------------------------------------------------------
   Maintenance Entity     : me-10               ME Index     : 1
   Tunnel Name            : 101              MP Type      : MEP
   Oper Status            : UP
------------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled


PE2#show ietf meg summary

Total Number of MEGs configured : 1
-------------------------------------------------------------------------------
MEG-Name             Service-Type    ME-Name              MP Type    Oper
Status
-------------------------------------------------------------------------------
meg-10                VC          me-10                 MEP        UP
```


Data Link Service

P1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-5`	Configure the MEG name as meg-5.
`(config-ietf-meg)#service type datalink`	Configure the service type as data link.
`(config-ietf-meg)#me me-5 datalink`	Configure the ME name as me-5.
`(config-ietf-me)#service datalink eth3`	Associate data link eth3 with the ME.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-5`	Configure the MEG name as meg-5.
`(config-ietf-meg)#service type datalink`	Configure the service type as data link.
`(config-ietf-meg)# mmee-5 datalink`	Configure the ME name as me-5.
`(config-ietf-me)#service datalink eth3`	Associate data link eth3 with the ME.

Validation

P1

```
P1#show ietf meg brief

Total Number of MEGs configured : 1
==============================================================================
Maintenance Entity Group   : meg-5                MEG Index    : 1
Service Type               : Datalink             MP Location  : Per-node
-------------------------------------------------------------------------------
   Maintenance Entity      : me-5                 ME Index     : 1
   Provider Interface Name: eth3                  Interface Id : 10.1.1.2
   Oper Status             : UP
------------------------------------------------------------------------------
      CC-CV                : Disabled
      Loopback             : Disabled
      Lock                 : Disabled
      Fault-Management     : Disabled
      Loss-Measurement     : Disabled
      Delay-Measurement    : Disabled


P1#show ietf meg summary

Total Number of MEGs configured : 1
-------------------------------------------------------------------------------
MEG-Name             Service-Type    ME-Name             MP Type    Oper
Status
-------------------------------------------------------------------------------
meg-5                Datalink        me-5                MEP        UP
```

```
P1#show ietf meg brief

Total Number of MEGs configured : 1
==============================================================================
Maintenance Entity Group   : meg-5              MEG Index    : 1
Service Type               : Datalink           MP Location  : Per-node
-------------------------------------------------------------------------------
   Maintenance Entity      : me-5               ME Index     : 1
   Provider Interface Name: eth3                Interface Id : 10.1.1.1
   Oper Status             : UP
------------------------------------------------------------------------------
      CC-CV                : Disabled
      Loopback             : Disabled
      Lock                 : Disabled
      Fault-Management     : Disabled
      Loss-Measurement     : Disabled
      Delay-Measurement    : Disabled
```

P2

```
P2#show ietf meg summary

Total Number of MEGs configured : 1
------------------------------------------------------------------------------
MEG-Name              Service-Type    ME-Name              MP Type    Oper
Status
------------------------------------------------------------------------------
meg-5                 Datalink        me-5                 MEP        UP
```

Configuring MEGs Using ITU-T Identifiers

Refer to Figure 21-2 on page 284 for the topology.

Tunnel Service

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-c`	Configure the MEG name as meg-c.
`(config-itut-meg)#service type tunnel`	Configure the service type as tunnel.
`(config-itut-meg)#mep-id 1`	Configure the MEP identifier as 1.
`(config-itut-mp)#service tunnel tnl_co`	Associate tnl1_co with the ME.
`(config-itut-mp)#rmep-id 4 cc IN icc AIRTEL umc meg-c`	Configure the remote MEP.

P1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-c`	Configure the MEG name as meg-c.

`(config-itut-meg)#service type tunnel`	Configure the service type as tunnel.
`(config-itut-meg)#mip-id 2`	Configure the MIP identifier as 2.
`(config-itut-mp)#service tunnel tnl_co`	Associate tnl_co with the ME.
`(config-itut-mp)#rmep-id 4 cc IN icc AIRTEL umc meg-c fwd`	Configure the forward remote MEP.
`(config-itut-mp)#rmep-id 1 cc IN icc AIRTEL umc meg-c rev`	Configure the reverse remote MEP.

P2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-c`	Configure the MEG name as meg-c.
`(config-itut-meg)#service type tunnel`	Configure the service type as tunnel.
`(config-itut-meg)#mip-id 3`	Configure the MIP identifier as 3.
`(config-itut-mp)#service tunnel tnl_co`	Associate tnl_co with the ME.
`(config-itut-mp)#rmep-id 4 cc IN icc AIRTEL umc meg-c fwd`	Configure the forward remote MEP.
`(config-itut-mp)#rmep-id 1 cc IN icc AIRTEL umc meg-c rev`	Configure the reverse remote MEP.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-c`	Configure the MEG name as meg-c.
`(config-itut-meg)#service type tunnel`	Configure the service type as tunnel.
`(config-itut-meg)#mep-id 4`	Configure the MEP identifier as 4.
`(config-itut-mp)#service tunnel tnl_co`	Associate tnl_co with the ME.
`(config-itut-mp)#rmep-id 1 cc IN icc AIRTEL umc meg-c`	Configure the remote MEP.

Validation

```
PE1#sh itut meg brief
Maintenance Entity Group   : INAIRTEL/meg-c      MEG Index    : 2
Service Type               : Tunnel              MEG Level    : 7
   ---------------------------------------------------------------------------
   MP-ID                   : 1                   MP Type      : MEP
   Tunnel Name             : tnl_co              Oper Status  : UP
   RMEP
                   : INAIRTEL/meg-c,4
P1#show itut meg brief
Maintenance Entity Group   : INAIRTEL/meg-c      MEG Index    : 2
Service Type               : Tunnel              MEG Level    : 7
   ---------------------------------------------------------------------------
   MP-ID                   : 2                   MP Type      : MIP
   Tunnel Name             : tnl_co              Oper Status  : UP
   RMEP                    : INAIRTEL/meg-c,4     Direction    : FWD
```

```
    --------------------------------------------------------------------------------
    MP-ID                : 2                    MP Type      : MIP
    Tunnel Name          : tnl_co               Oper Status  : UP
    RMEP
                    : INAIRTEL/meg-c,1     Direction    : REV
P2#show itut meg brief
Maintenance Entity Group  : INAIRTEL/meg-c      MEG Index    : 2
Service Type              : Tunnel              MEG Level    : 7
    --------------------------------------------------------------------------------
    MP-ID                : 3                    MP Type      : MIP
    Tunnel Name          : tnl_co               Oper Status  : UP
    RMEP                 : INAIRTEL/meg-c,4      Direction    : FWD

    --------------------------------------------------------------------------------
    MP-ID                : 3                    MP Type      : MIP
    Tunnel Name          : tnl_co               Oper Status  : UP
    RMEP                 : INAIRTEL/meg-c,1      Direction    : REV

PE2#sh itut meg brief
Maintenance Entity Group  : INAIRTEL/meg-c      MEG Index    : 2
Service Type              : Tunnel              MEG Level    : 7
    --------------------------------------------------------------------------------
    MP-ID                : 4                    MP Type      : MEP
    Tunnel Name          : tnl_co               Oper Status  : UP
    RMEP                 : INAIRTEL/meg-c,1
```

Virtual Circuit Service

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-v`	Configure the MEG name as meg-v.
`(config-itut-meg)#service type vc`	Configure the service type as virtual circuit.
`(config-itut-meg)#mep-id 1111`	Configure the MEP identifier as 1111.
`(config-itut-mp)#service vc 101`	Associate virtual circuit 101 with the ME.
`(config-itut-mp)#rmep-id 4444 cc IN icc AIRTEL umc meg-v`	Configure the remote MEP.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-v`	Configure the MEG name as meg-1
`(config-itut-meg)#service type vc`	Configure the service type as virtual circuit.
`(config-itut-meg)#mep-id 4444`	Configure the ME name as me-1.
`(config-itut-mp)#service vc 101`	Associate virtual circuit 101 with the ME.
`(config-itut-mp)#rmep-id 1111 cc IN icc AIRTEL umc meg-v`	Configure the remote MEP.

Validation

```
PE1#sh itut meg brief
Maintenance Entity Group   : INAIRTEL/meg-v      MEG Index    : 4
Service Type               : VC                  MEG Level    : 7
   ---------------------------------------------------------------------------
   MP-ID                   : 1111
   VC Id                   : 101                 Oper Status  : UP
   RMEP                    : INAIRTEL/meg-v,4444

   ---------------------------------------------------------------------------

PE2#sh itut meg brief
Maintenance Entity Group   : INAIRTEL/meg-v      MEG Index    : 4
Service Type               : VC                  MEG Level    : 7
   ---------------------------------------------------------------------------
   MP-ID                   : 4444
   VC Id                   : 101                 Oper Status  : UP
   RMEP                    : INAIRTEL/meg-v,1111

   ---------------------------------------------------------------------------
```

Data Link Service

P1 (OAM)

`(config)#interface eth3`	Enter interface mode for eth1
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1
`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-d level 5`	Configure the MEG name as meg-d at level 5.
`(config-itut-meg)#service type datalink`	Configure the service type as data link.
`(config-itut-meg)#mep-id 2222`	Configure the MEP identifier as 2222.
`(config-itut-mp)#service datalink eth3`	Associate data link eth3 with the ME.
`(config-itut-mp)#rmep-id 3333 cc IN icc AIRTEL umc meg-d`	Configure the remote MEP.

P2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#interface eth2`	Enter interface mode for eth1
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1
`(config)#itut meg meg-d level 5`	Configure the MEG name as meg-d at level 5.
`(config-itut-meg)#service type datalink`	Configure the service type as data link.
`(config-itut-meg)#mep-id 3333`	Configure the MEP identifier as 3333

`(config-itut-mp)#service datalink eth2`	Associate data link eth3 with the ME.
`(config-itut-mp)#rmep-id 2222 cc IN icc AIRTEL umc meg-d`	Configure the remote MEP.

Validation

```
P1#sh itut meg brief
Maintenance Entity Group  : INAIRTEL/meg-d      MEG Index    : 3
Service Type              : Datalink            MEG Level    : 5
   ---------------------------------------------------------------------------
   MP-ID                  : 2222
   Provider Interface Name: eth3                Oper Status  : UP
   RMEP                   : INAIRTEL/meg-d,3333

P2#sh itut meg brief
Maintenance Entity Group  : INAIRTEL/meg-d      MEG Index    : 3
Service Type              : Datalink            MEG Level    : 5
   ---------------------------------------------------------------------------
   MP-ID                  : 3333
   Provider Interface Name: eth2                Oper Status  : UP
   RMEP                   : INAIRTEL/meg-d,2222
```


CHAPTER 26 MPLS-TP LSP Ping and Traceroute

This chapter provides configuration examples using the LSP ping and traceroute commands which can be used to validate configurations. The examples are based on co-routed tunnel configurations. For details about configuring a co-routed tunnel, refer to Co-Routed Bi-Directional Tunnel on page 277. For information about co-routed connectivity, refer to Figure 20-2 on page 272.

Note: LSP ping does not support the "Associated Reverse Path Travels in Different Node" configuration as described in Associated Bi-Directional Tunnel on page 280.

LSP Ping for MPLS-TP LSP

PE1 (OAM) - Ping to Endpoint

#ping mpls-tp meg-name meg-1 me-name me-1 detail	Initiate the LSP Ping from PE1 to PE2 with meg-1 and me-1.

```
PE1#ping mpls-tp meg-name meg-1 me-name me-1 detail
Sending 5 MPLS Echos to MEG: meg-1 and ME: me-1, 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 Global_id: 300 Node_id: 3.3.3.3 22.32 ms
! seq_num = 2 Global_id: 300 Node_id: 3.3.3.3 19.68 ms
! seq_num = 3 Global_id: 300 Node_id: 3.3.3.3 15.73 ms
! seq_num = 4 Global_id: 300 Node_id: 3.3.3.3 11.77 ms
! seq_num = 5 Global_id: 300 Node_id: 3.3.3.3 7.82 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 7.82/15.07/22.32
```

PE1 (OAM) - Ping to MIP Transit Node

#ping mpls-tp meg-name meg-1 me-name me-1 detail mip global-id 200 node-id 2.2.2.2 ttl 1	Initiate the LSP-Ping from PE1 to P1 with meg-1, me-1, mip global ID and node ID.

```
PE1#ping mpls-tp meg-name meg-1 me-name me-1 detail mip global-id 200 node-id
2.2.2.2 ttl 1
Sending 5 MPLS Echos to MEG: meg-1 and ME: me-1, 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

R seq_num = 1 Global_id: 200 Node_id: 2.2.2.2 16.62 ms
R seq_num = 5 Global_id: 200 Node_id: 2.2.2.2 0.24 ms
R seq_num = 2 Global_id: 200 Node_id: 2.2.2.2 12.28 ms
R seq_num = 3 Global_id: 200 Node_id: 2.2.2.2 8.33 ms
R seq_num = 4 Global_id: 200 Node_id: 2.2.2.2 4.37 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.24/8.43/16.62
```

PE2 (OAM) - Ping to Ingress Node

`#ping mpls-tp meg-name meg-1 me-name me-1 detail`	Initiate the LSP-Ping from PE2 to PE1 with meg-1 and me-1.

```
PE2#ping mpls-tp meg-name meg-1 me-name me-1 detail
Sending 5 MPLS Echos to MEG: meg-1 and ME: me-1, 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 Global_id: 100 Node_id: 1.1.1.1 0.50 ms
! seq_num = 2 Global_id: 100 Node_id: 1.1.1.1 0.39 ms
! seq_num = 3 Global_id: 100 Node_id: 1.1.1.1 0.41 ms
! seq_num = 4 Global_id: 100 Node_id: 1.1.1.1 0.43 ms
! seq_num = 5 Global_id: 100 Node_id: 1.1.1.1 0.34 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.34/0.42/0.50
```

PE2 (OAM) - Ping to MIP Node

`#ping mpls-tp meg-name meg-1 me-name me-1 detail mip global-id 200 node-id 2.2.2.2 ttl 1`	Initiate the LSP ping from PE2 to P1 with meg-1, me-1, mip global ID and node ID.

```
PE2#ping mpls-tp meg-name meg-1 me-name me-1 detail mip global-id 200 node-id
2.2.2.2 ttl 1
```



```
Sending 5 MPLS Echos to MEG: meg-1 and ME: me-1, 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

R seq_num = 1 Global_id: 200 Node_id: 2.2.2.2 0.26 ms
R seq_num = 2 Global_id: 200 Node_id: 2.2.2.2 0.14 ms
R seq_num = 3 Global_id: 200 Node_id: 2.2.2.2 0.20 ms
R seq_num = 4 Global_id: 200 Node_id: 2.2.2.2 0.20 ms
R seq_num = 5 Global_id: 200 Node_id: 2.2.2.2 0.22 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.14/0.20/0.26
```

LSP Ping for Virtual Circuit

PE1 (OAM)

#ping mpls-tp meg-name meg-2 me-name me-2 detail	Initiate the LSP ping from PE1 to PE2 with meg-2 and me-2.

```
PE1#ping mpls-tp meg-name meg-2 me-name me-2 detail
Sending 5 MPLS Echos to MEG: meg-2 and ME: me-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 Global_id: 300 Node_id: 3.3.3.3 22.32 ms
! seq_num = 2 Global_id: 300 Node_id: 3.3.3.3 19.68 ms
! seq_num = 3 Global_id: 300 Node_id: 3.3.3.3 15.73 ms
! seq_num = 4 Global_id: 300 Node_id: 3.3.3.3 11.77 ms
! seq_num = 5 Global_id: 300 Node_id: 3.3.3.3 7.82 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 7.82/15.07/22.32
```


PE2 (OAM)

#ping mpls-tp meg-name meg-2 me-name me-2 detail	Initiate the LSP- Ping from PE2 to PE1 with meg-2 and me-2.

```
PE2#ping mpls-tp meg-name meg-2 me-name me-2 detail
Sending 5 MPLS Echos to MEG: meg-2 and ME: me-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 Global_id: 100 Node_id: 1.1.1.1 0.50 ms
! seq_num = 2 Global_id: 100 Node_id: 1.1.1.1 0.39 ms
! seq_num = 3 Global_id: 100 Node_id: 1.1.1.1 0.41 ms
! seq_num = 4 Global_id: 100 Node_id: 1.1.1.1 0.43 ms
! seq_num = 5 Global_id: 100 Node_id: 1.1.1.1 0.34 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.34/0.42/0.50
```

LSP Traceroute

PE1 (OAM)

#trace mpls-tp meg-name meg-1 me-name me-1 detail	Initiate the Trace-route from PE1 to PE2 with meg-1 and me-1.

```
At PE1

PE1#trace mpls-tp meg-name meg-1 me-name me-1 detail
Tracing MPLS Label Switched Path to MEG: meg-1 and ME: me-1, 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

R 1 Global_id: 200 Node_id: 2.2.2.2 [Labels: 1002] 0.40 ms
```



```
! 2 Global_id: 300 Node_id: 3.3.3.3 0.36 ms
```

PE2 (OAM)

#trace mpls-tp meg-name meg-1 me-name me-1 detail	Initiate the Trace-route from PE2 to PE1 with meg-2 and me-2.

```
PE2#trace mpls-tp meg-name meg-1 me-name me-1 detail
Tracing MPLS Label Switched Path to MEG: meg-1 and ME: me-1, 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

R 1 Global_id: 200 Node_id: 2.2.2.2 [Labels: 2002] 0.22 ms
! 2 Global_id: 300 Node_id: 1.1.1.1 0.38 ms
```

CHAPTER 27 MPLS-TP BFD for LSPs

This chapter provides examples of configuring and validating Bidirectional Forwarding Detection (BFD) setups. The examples are based on co-routed tunnel configurations. For details about configuring a co-routed tunnel, refer to Co-Routed Bi-Directional Tunnel. For information about co-routed connectivity topology, refer to Figure 20-2.

BFD LSP

Follow the steps in the tables to configure BFD for MPLS-TP LSPs.

PE1 (OAM)

#configure terminal	Enter configure mode.
(config)#mpls-tp bfd meg-name meg-1 me-name me-1	Configure the BFD session for meg-1 associated with tunnel tnl1.

PE2 (OAM)

#configure terminal	Enter configure mode.
(config)#mpls-tp bfd meg-name meg-1 me-name me-1	Configure the BFD session for meg-1 associated with tunnel tnl1.

Validation

PE1

```
PE1#sh bfd session
Sess-Idx   Remote-Disc  Lower-Layer  Sess-Type   Sess-State  UP-Time   Remote-
Addr
1          7            MPLS-TP      Single-Hop  Up          00:00:09
Number of Sessions:    1


PE1#sh bfd session detail
======================================================

Session Index : 1
Lower Layer : MPLS-TP                      Version : 1
Session State : Up
Local Discriminator : 1                    Remote Discriminator : 7
MEG Name : meg-1
ME Name : me-1
Path Type : MPLS-TP LSP
Options :
```

```
Diagnostics : None

Timers in Milliseconds :
Min Tx: 50              Min Rx: 50              Multiplier: 5
Neg Tx: 0               Neg Rx: 0               Neg detect mult: 5
Storage type : 2
Sess down time : 00:00:00
Sess discontinue time : 00:00:00
Bfd GTSM Disabled

Counters values:
Pkt In : 0000000000000000               Pkt Out : 0000000000000000
UP Count : 0                            UPTIME : 00:00:42

Protocol Client Info:
NSM-> Client ID: 1      Flags: 4
----------------------------------------------------------
Number of Sessions:    1
```

PE2

```
PE2#sh bfd session
Sess-Idx   Remote-Disc  Lower-Layer  Sess-Type   Sess-State  UP-Time   Remote-
Addr
7          1            MPLS-TP      Single-Hop  Up          00:00:26
Number of Sessions:    1


PE2#sh bfd session detail
======================================================

Session Index : 7
Lower Layer : MPLS-TP                   Version : 1
Session State : Up
Local Discriminator : 7                 Remote Discriminator : 1
MEG Name : meg-1
ME Name : me-1
Path Type : MPLS-TP LSP
Options :

Diagnostics : None

Timers in Milliseconds :
Min Tx: 50              Min Rx: 50              Multiplier: 5
Neg Tx: 0               Neg Rx: 0               Neg detect mult: 5
Storage type : 2
Sess down time : 00:00:00
Sess discontinue time : 00:00:00
Bfd GTSM Disabled

Counters values:
Pkt In : 0000000000000000               Pkt Out : 0000000000000000
UP Count : 0                            UPTIME : 00:00:31

Protocol Client Info:
NSM-> Client ID: 1      Flags: 4
----------------------------------------------------------
```

```
Number of Sessions:    1
PE2#
```

BFD Pseudowire

Follow the steps in the tables to configure BFD pseudowire for MPLS-TP LSPs.

PE1 (OAM)

#configure terminal	Enter configure mode.
(config)#mpls-tp bfd meg-name meg-2 me-name me-2	Configure the BFD session for meg-2 associated with VC 101.

PE1 (OAM)

#configure terminal	Enter configure mode.
(config)#mpls-tp bfd meg-name meg-2 me-name me-2	Configure the BFD session for meg-2 associated with VC 101.

Validation

Validations are displayed in the following examples. The commands used:

- show bfd session
- show bfd session detail

PE1

```
PE1#sh bfd session
Sess-Idx   Remote-Disc  Lower-Layer  Sess-Type   Sess-State  UP-Time   Remote-
Addr
2          8            MPLS-TP      Single-Hop  Up          00:02:15
Number of Sessions:    1


PE1#sh bfd session detail
======================================================

Session Index : 2
Lower Layer : MPLS-TP                    Version : 1
Session State : Up
Local Discriminator : 2                  Remote Discriminator : 8
MEG Name : meg-2
ME Name : me-2
Path Type : MPLS-TP PW
Options :

Diagnostics : None
```

```
Timers in Milliseconds :
Min Tx: 50              Min Rx: 50              Multiplier: 5
Neg Tx: 0               Neg Rx: 0               Neg detect mult: 5
Storage type : 2
Sess down time : 00:00:00
Sess discontinue time : 00:00:00
Bfd GTSM Disabled

Counters values:
Pkt In : 0000000000000000               Pkt Out : 0000000000000000
UP Count : 0                            UPTIME : 00:02:19

Protocol Client Info:
NSM-> Client ID: 1       Flags: 4
----------------------------------------------------------
Number of Sessions:    1


PE2#sh bfd session
Sess-Idx   Remote-Disc  Lower-Layer  Sess-Type   Sess-State  UP-Time   Remote-
Addr
8          2            MPLS-TP      Single-Hop  Up          00:02:36
Number of Sessions:    1
```

PE2

```
PE2#sh bfd session detail
======================================================

Session Index : 8
Lower Layer : MPLS-TP                   Version : 1
Session State : Up
Local Discriminator : 8                 Remote Discriminator : 2
MEG Name : meg-2
ME Name : me-2
Path Type : MPLS-TP PW
Options :

Diagnostics : None

Timers in Milliseconds :
Min Tx: 50              Min Rx: 50              Multiplier: 5
Neg Tx: 0               Neg Rx: 0               Neg detect mult: 5
Storage type : 2
Sess down time : 00:00:00
Sess discontinue time : 00:00:00
Bfd GTSM Disabled

Counters values:
Pkt In : 0000000000000000               Pkt Out : 0000000000000000
UP Count : 0                            UPTIME : 00:02:40

Protocol Client Info:
NSM-> Client ID: 1       Flags: 4
----------------------------------------------------------
Number of Sessions:    1
```

CHAPTER 28 MPLS-TP Lock Instruct and Loopback

This chapter contains configuration examples for the MPLS-TP Lock Instruct and Loopback features.

Overview

The OAM (Operations, Administration, and Maintenance) plays a significant role in providing methods for fault management and performance monitoring in both the transport and the service layers in order to improve their ability to support services with guaranteed and strict Service Level Agreements (SLA), while reducing their operational costs. OAM for MPLS-TP consists of a comprehensive set of fault indication and performance monitoring capabilities.

Some of the MPLS-TP OAM functions are:

- Continuity check and connectivity verification (CCCV)
- Remote Defect Indication
- Route Tracing
- Alarm reporting
- Lock Instruct and Loopback
- Packet loss and delay measurement

Lock and loopback are two useful OAM functions in a transport profile network.

Lock Function

The lock function enables an operator to lock a transport path such that it does not carry client traffic, but can continue to carry OAM messages and may carry test traffic.

Locking a transport path

When a MEP receives a Lock command from an network management service (NMS) or another management process, it must take the transport path out of service. That is, it must stop injecting or forwarding traffic onto the LSP, PW, or bidirectional section that has been locked.

When locking a transport path, the NMS or management process is required to send a Lock command to both ends of the transport path. If rapid coordination of lock state is to be achieved, then as soon as the transport path has been locked, the MEP must send an Lock Instruct (LI) message targeting the MEP at the other end of the locked transport path until it is unlocked by management process.

Unlocking a transport path

Unlock is used to request that a MEP bring the previously locked transport path back in service. When a MEP receives an Unlock command from a management process, it must cease sending LI messages. If the MEP is still receiving LI messages, the transport path must remain out of service. This means that to unlock a transport path, the management process has to send an Unlock command to the MEPs at both ends.

Loopback Function

The loopback function is used to test the integrity of a transport path from a MEP up any other node in the same MEG.This is achieved by setting the target node into loopback mode, and transmitting a pattern of test data from the MEP. The target node loops all received data back toward the originator, and the MEP extracts the test data and compares it with what was sent.

Loopback is a function that enables a receiving MEP or MIP to return traffic to the sending MEP when in the loopback state. This state corresponds to the situation where, at a given node, a forwarding plane loop is configured, and the incoming direction of a transport path is cross-connected to the outgoing reverse direction. Therefore, except in the case of early TTL expiration, traffic sent by the source is received by the source.

It should be noted that the data-plane loopback function itself is applied to data-plane loopback points residing on different interfaces from MEPs. All traffic, including both payload and OAM, received on the looped-back interface is sent on the reverse direction of the transport path.

The Loopback features supports:

- Locking and unlocking of tunnel and pseudowire MEPs
- Loopback for tunnel MEG and MEP, and for PW MEPs

Lock-Instruct Configuration for MEG on Tunnel

A co-routed bidirectional tunnel is used as the basis for this configuration; see Co-Routed Bi-Directional Tunnel. Refer to Figure 21-1 for the topology used for this configuration.

PE1 - OAM

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-1`	Configure MEG name as meg-1.
`(config-ietf-meg)#service type tunnel`	Configure service type as tunnel.
`(config-ietf-meg)#me me-1 tunnel`	Configure ME name as me-1.
`(config-ietf-me)#service tunnel tnl1`	Configure service tunnel tnl1 as associated with the ME.
`(config-ietf-me)#lock-instruct refresh-timer 50`	Configure lock with refresh-timer value 50 seconds for PW path from PE1 to PE2.Refresh-timer value range is from 1 to 255 seconds. **Note:** Default Refresh-timer value is 1 seconds.

PE2 - OAM

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-1`	Configure MEG name as meg-1.
`(config-ietf-meg)#service type tunnel`	Configure service type as tunnel.
`(config-ietf-meg)#me me-1 tunnel`	Configure ME name as me-1.
`(config-ietf-me)#service tunnel tnl1`	Configure service tunnel tnl1 as associated with the ME.

Validation

Show ietf meg brief, show ietf meg summary, show ietf meg <meg-name> me <me-name>

Note: At PE1 or PE2 in output of `show ietf meg meg-1`, a non-zero refresh interval means LI messages are sent at that interval, while zero means no LI message is sent, but the MEG but goes to lock mode after receiving LI messages from node where the Lock was applied.

PE1

```
PE1#show ietf meg meg-1

=============================================================================>
Maintenance Entity Group  : meg-1               MEG Index     : 1
Service Type              : Tunnel              MP Location   : Per-node
----------------------------------------------------------------------------->
   Maintenance Entity     : me-1                ME Index      : 1
   Tunnel Name            : tnl1                MP Type       : MEP
   Oper Status            : UP
<--------------------------------------------------------------------------->
      Lock                : Valid (Refresh Interval: 50)


PE1#show ietf meg brief

Total Number of MEGs configured : 1
============================================================================
Maintenance Entity Group  : meg-1               MEG Index     : 1
Service Type              : Tunnel              MP Location   : Per-node
------------------------------------------------------------------------------
   Maintenance Entity     : me-1                ME Index      : 1
   Tunnel Name            : tnl1                MP Type       : MEP
   Oper Status            : UP
------------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Enabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled

=============================================================================

PE1#show ietf meg summary

Total Number of MEGs configured : 1
------------------------------------------------------------------------------
MEG-Name             Service-Type    ME-Name       MP Type    Oper Status
------------------------------------------------------------------------------
meg-1                Tunnel          me-1                 MEP        UP
```

PE2

```
PE2#show ietf meg meg-1

=============================================================================>
Maintenance Entity Group  : meg-1               MEG Index     : 1
Service Type              : Tunnel              MP Location   : Per-node
```

```
    ---------------------------------------------------------------------------->
       Maintenance Entity      : me-1                  ME Index      : 1
       Tunnel Name             : tnl1                  MP Type       : MEP
       Oper Status             : UP
    --------------------------------------------------------------------------->
          Lock                : Valid (Refresh Interval: 0)


    PE2#show ietf meg brief

    Total Number of MEGs configured : 1
    ===========================================================================
    Maintenance Entity Group   : meg-1                 MEG Index     : 1
    Service Type               : Tunnel                MP Location   : Per-node
    -----------------------------------------------------------------------------
       Maintenance Entity      : me-1                  ME Index      : 1
       Tunnel Name             : tnl1                  MP Type       : MEP
       Oper Status             : UP
    -----------------------------------------------------------------------------
          CC-CV                : Disabled
          Loopback             : Disabled
          Lock                 : Enabled
          Fault-Management     : Disabled
          Loss-Measurement     : Disabled
          Delay-Measurement    : Disabled

    ===========================================================================

    PE2#show ietf meg summary

    Total Number of MEGs configured : 1
    -----------------------------------------------------------------------------
    MEG-Name                 Service-Type     ME-Name         MP Type     Oper Status
    -----------------------------------------------------------------------------
    meg-1                    Tunnel           me-1                 MEP         UP
```

Loopback Configuration for MEG on Tunnel

A co-routed bidirectional tunnel is used as the basis for this configuration; see Co-Routed Bi-Directional Tunnel. Refer to Figure 21-1 for the topology used for this configuration.

PE1 - OAM

`#configure terminal`	Enter configure mode..
`(config)#ietf meg meg-1`	Configure the MEG name as meg-1.
`(config-ietf-meg)#service type tunnel`	Configure service type as tunnel.
`(config-ietf-meg)#me me-1 tunnel`	Configure ME name as me-1.
`(config-ietf-me)#service tunnel tnl1`	Configure service tunnel tnl1 as associated with the ME.
`(config-ietf-me)#lock-instruct refresh-timer 50`	Configure lock with refresh-timer value 50 seconds for PW path from PE1 to PE2. Refresh-timer value range is from 1 to 255 seconds. **Note:** Default refresh-timer value is 1 seconds.

PE2 - OAM

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-1`	Configure the MEG name as meg-1
`(config-ietf-meg)#``service type tunnel`	Configure service type as tunnel
`(config-ietf-meg)#``me me-1 tunnel`	Configure ME name as me-1
`(config-ietf-me)#``service tunnel tnl1`	Configure service tunnel tnl1 as associated with the ME
`(config-ietf-me)#``loopback`	Configure loopback on meg-1 at PE2. **Note**: TP path from PE1 to PE2 should be locked before applying loopback, otherwise loopback status displays as invalid in output of `show ietf meg <meg_name>` command.

Validation

PE1

```
PE1#show ietf meg meg-1

===============================================================================>
Maintenance Entity Group   : meg-1                 MEG Index     : 1
Service Type               : Tunnel                MP Location   : Per-node
------------------------------------------------------------------------------->
   Maintenance Entity      : me-1                  ME Index      : 1
   Tunnel Name             : tnl1                  MP Type       : MEP
   Oper Status             : UP
------------------------------------------------------------------------------->
      Lock                 : Valid (Refresh Interval: 50)


PE1#show ietf meg brief

Total Number of MEGs configured : 1
=============================================================================
Maintenance Entity Group   : meg-1                 MEG Index     : 1
Service Type               : Tunnel                MP Location   : Per-node
-------------------------------------------------------------------------------
   Maintenance Entity      : me-1                  ME Index      : 1
   Tunnel Name             : tnl1                  MP Type       : MEP
   Oper Status             : UP
-------------------------------------------------------------------------------
      CC-CV                : Disabled
      Loopback             : Disabled
      Lock                 : Enabled
      Fault-Management     : Disabled
      Loss-Measurement     : Disabled
      Delay-Measurement    : Disabled

=============================================================================

PE1#show ietf meg summary

Total Number of MEGs configured : 1
```

```
---------------------------------------------------------------------------------
MEG-Name             Service-Type    ME-Name       MP Type    Oper Status
---------------------------------------------------------------------------------
meg-1                Tunnel          me-1                 MEP        UP
```

PE2

```
PE2#show ietf meg meg-1

====================================================================================>
Maintenance Entity Group  : meg-1              MEG Index    : 1
Service Type              : Tunnel             MP Location  : Per-node
------------------------------------------------------------------------------------>
   Maintenance Entity     : me-1               ME Index     : 1
   Tunnel Name            : tnl1               MP Type      : MEP
   Oper Status            : UP
------------------------------------------------------------------------------------>
      Lock               : Valid (Refresh Interval: 0)

      Loopback            : Valid

PE2#show ietf meg brief

Total Number of MEGs configured : 1
=================================================================================
Maintenance Entity Group  : meg-1              MEG Index    : 1
Service Type              : Tunnel             MP Location  : Per-node
---------------------------------------------------------------------------------
   Maintenance Entity     : me-1               ME Index     : 1
   Tunnel Name            : tnl1                MP Type      : MEP
   Oper Status            : UP
-------------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Enabled
      Lock                : Enabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled

=================================================================================

PE2#show ietf meg summary

Total Number of MEGs configured : 1
---------------------------------------------------------------------------------
MEG-Name             Service-Type    ME-Name         MP Type    Oper Status
---------------------------------------------------------------------------------
meg-1                Tunnel          me-1                 MEP        UP
```


CHAPTER 29 MPLS-TP Loss and Delay Measurement

This chapter contains configuration examples for the MPLS-TP Loss and Delay Measurement features.

Proactive Loss Measurement

PE1

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg1`	Configure the MEG-name as meg1.
`(config-ietf-meg)#me me1 tunnel`	Configure ME-name as me1.
`(config-ietf-me)#service tunnel tunnel-1`	Configure ME as associated with the tunnel-1.
`(config-ietf-me)#loss-measurement`	Initiate proactive loss-measurement session for meg1 and me1. Interval can be configured in the range of <1-5>.

Validation

The command `show ietf meg brief` displays Loss-Measurement as Enabled if the command to initiate proactive LM is a success.

The command `show mpls-tp loss-measurement meg-name meg1 me-name` me1: Displays any configuration errors or statistics.

PE1

```
PE1#sh ietf meg brief

Total Number of MEGs configured : 1
==============================================================================
Maintenance Entity Group  : meg1              MEG Index    : 2
Service Type              : Tunnel            MP Location  : Per-node
------------------------------------------------------------------------------
   Maintenance Entity     : me1               ME Index     : 1
   Tunnel Name            : tunnel-1          MP Type      : MEP
   Oper Status            : UP
   ---------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Enabled
      Delay-Measurement   : Disabled

PE1#sh mpls-tp loss-measurement meg-name meg1 me-name me1

Codes:
'Q' - Request not sent,
```

```
'a' - Invalid data format,        'b' - Initialization in progress,
'c' - Data reset occurred,        'd' - Resource temporarily unavailable,
'e' - Unspecified error,          'f' - Unsupported version,
'g' - Unsupported control code,   'h' - Unsupported data format,
'i' - Authentication failure,     'j' - Invalid destination node Id,
'k' - Connection mismatch,        'l' - Unsupported mandatory TLV,
'm' - Unsupported query interval, 'n' - Admin block,
'o' - Resource unavailable,       'p' - Resource released,
'q' - Invalid message,            'r' - Protocol error

Q No active loss-measurement session on the ME
```

On-demand Loss Measurement

PE1 - OAM

#mpls-tp loss-measurement meg-name meg1 me-name me1	Initiate on-demand loss measurement session for meg1 and me1.

Validation

```
PE1#mpls-tp loss-measurement meg-name meg1 me-name me1
Initiating loss measurement on MEG: meg1 and ME: me1,
duration is 60 seconds, interval is 100 milliseconds.

Codes:
'Q' - Request not sent,
'a' - Invalid data format,        'b' - Initialization in progress,
'c' - Data reset occurred,         'd' - Resource temporarily unavailable,
'e' - Unspecified error,          'f' - Unsupported version,
'g' - Unsupported control code,   'h' - Unsupported data format,
'i' - Authentication failure,     'j' - Invalid destination node Id,
'k' - Connection mismatch,        'l' - Unsupported mandatory TLV,
'm' - Unsupported query interval, 'n' - Admin block,
'o' - Resource unavailable,       'p' - Resource released,
'q' - Invalid message,            'r' - Protocol error

Type 'Ctrl+C' to abort

Q Operation failed
```

Proactive Delay Measurement

PE1 - OAM

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg1`	Configure MEG name as meg1.
`(config-ietf-meg)#me me1 tunnel`	Configure ME name as me1
`(config-ietf-me)#service tunnel tunnel-1`	Configure ME as associated with tunnel-1.
`(config-ietf-me)#delay-measurement`	Initiate proactive delay-measurement session for meg1 and me1. Interval can be configured in the range of <1-4>.

Validation

The `show ietf meg brief` command displays Delay-Measurement as Enabled if the command to initiate proactive DM is a success.

The `show mpls-tp delay-measurement meg-name meg1 me-name me1` command displays any configuration errors or statistics.

PE1

```
PE1#sh ietf meg brief

Maintenance Entity Group  : meg1                 MEG Index    : 2
Service Type              : Tunnel               MP Location  : Per-node
-------------------------------------------------------------------------------
   Maintenance Entity     : me1                  ME Index     : 1
   Tunnel Name            : tunnel-1             MP Type      : MEP
   Oper Status            : UP
-------------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Enabled

PE1#sh mpls-tp delay-measurement meg-name meg1 me-name me1

Codes:
'Q' - Request not sent,
'a' - Invalid data format,        'b' - Initialization in progress,
'c' - Data reset occurred,         'd' - Resource temporarily unavailable,
'e' - Unspecified error,          'f' - Unsupported version,
'g' - Unsupported control code,   'h' - Unsupported data format,
'i' - Authentication failure,     'j' - Invalid destination node Id,
'k' - Connection mismatch,        'l' - Unsupported mandatory TLV,
'm' - Unsupported query interval, 'n' - Admin block,
'o' - Resource unavailable,       'p' - Resource released,
'q' - Invalid message,            'r' - Protocol error
```

```
Q No active delay-measurement session on the ME
```

On-demand Delay Measurement

PE1 - OAM

`#mpls-tp delay-measurement meg-name meg1 me-name me1`	Initiate on-demand delay measurement session for meg1 and me1.

Validation

```
PE1#mpls-tp delay-measurement meg-name meg1 me-name me1
Initiating delay measurement on MEG: meg1 and ME: me1
duration is 60 seconds, interval is 1 second.

Codes:
'Q' - Request not sent,
'a' - Invalid data format,        'b' - Initialization in progress,
'c' - Data reset occurred,         'd' - Resource temporarily unavailable,
'e' - Unspecified error,          'f' - Unsupported version,
'g' - Unsupported control code,   'h' - Unsupported data format,
'i' - Authentication failure,     'j' - Invalid destination node Id,
'k' - Connection mismatch,        'l' - Unsupported mandatory TLV,
'm' - Unsupported query interval, 'n' - Admin block,
'o' - Resource unavailable,       'p' - Resource released,
'q' - Invalid message,            'r' - Protocol error

Type 'Ctrl+C' to abort

Q Operation failed
```


CHAPTER 30 MPLS-TP Fault Management Configuration

This chapter contains configuration examples for the MPLS-TP Fault Management (FM) features.

Overview

Proper operation of a transport network depends on the ability to quickly identify faults and focus attention on the root cause of the disruption. When a fault occurs in a server sub-layer, Fault Management OAM messages are sent to clients of that server so that alarms, which otherwise would be generated by subsequent disruptions to the clients, may be suppressed. This prevents a storm of alarms and allows operators to focus on the actual faulty elements of the network.

Topology

The diagram shows the topology example used in the configurations.

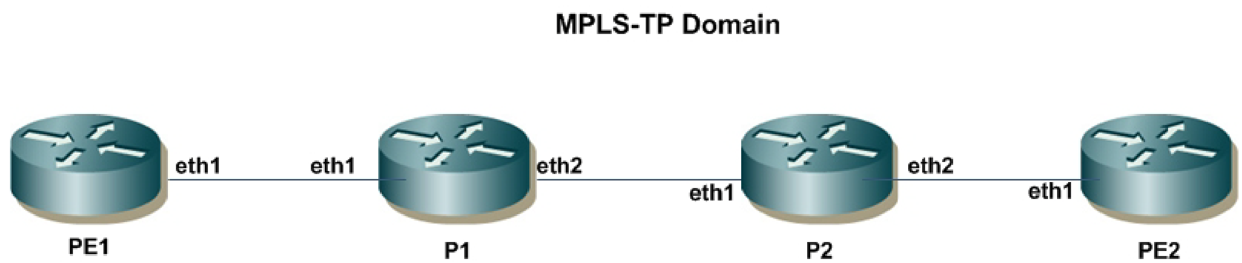


Figure 30-1: MPLS-TP Fault Management

Bidirectional Tunnel Configuration

PE1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 100 node-id 1.1.1.1`	Configure global ID as 100 and node ID as 1.1.1.1 on PE1 node.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure eth1 as provider interface and interface local ID as 10.1.1.1.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 400 4.4.4.4`	Configure Tunnel with Tunnel ID 1 originating from this node PE1 (global ID 100 and node ID 1.1.1.1) to destination at PE2 node (global ID 400 and node ID 4.4.4.4).
`(config-tnl)#tunnel-name tnl1`	Configure tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Configure mode of tunnel as bidirectional.

(config-bidir-tnl)#forward-path nhlfe-entry 1001 eth1	Configure NHLFE entry for PUSH the label at ingress for the forward path.
(config-bidir-tnl)#reverse-path ilm-entry 2003 eth1 pop	Configure ILM-entry for POP the label at ingress for the reverse path.

P1 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp global-id 200 node-id 2.2.2.2	Configure global ID and node ID at Transit (P1) node
(config)#interface eth1	Enter interface mode.
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure eth1 as provider interface and interface local ID as 10.1.1.1.
(config)#interface eth2	Enter interface mode.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure eth2 as provider interface and interface local ID as 20.1.1.1.
(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 400 4.4.4.4	Configure Tunnel with Tunnel ID 1 originating from this node PE1 (global ID 100 and node ID 1.1.1.1) to destination at PE2 node (global ID 400 and node ID 4.4.4.4).
(config-tnl)#tunnel-name tnl1	Configure tunnel with name tnl1
(config-tnl)#tunnel-mode bidirectional	Configure mode of tunnel as bidirectional.
(config-bidir-tnl)#forward-path ilm-entry 1001 eth1 swap 1002 eth2	Configure ILM entry to SWAP the labels at transit for the forward path.
(config-bidir-tnl)#reverse-path ilm-entry 2002 eth2 swap 2003 eth1	Configure ILM entry to SWAP the labels at transit for the reverse path.

P2 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp global-id 300 node-id 3.3.3.3	Configure global ID and node ID at Transit (P2) node.
(config)#interface eth1	Enter interface mode.
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure interface eth1 as provider interface and interface local ID as 10.1.1.1.
(config)#interface eth2	Enter interface mode.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure interface eth2 as provider interface and interface local ID as 20.1.1.1.
(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 400 4.4.4.4	Configure Tunnel with Tunnel ID 1 originating from this node PE1 (global ID 100 and node ID 1.1.1.1) to destination at PE2 node (global ID 400 and node ID 4.4.4.4).
(config-tnl)#tunnel-name tnl1	Configure tunnel with name tnl1
(config-tnl)#tunnel-mode bidirectional	Configure tunnel mode as bidirectional
(config-bidir-tnl)#forward-path ilm-entry 1002 eth1 swap 1003 eth2	Configure ILM entry to SWAP the labels at transit for the forward path.
(config-bidir-tnl)#reverse-path ilm-entry 2001 eth2 swap 2002 eth1	Configure ILM entry to be SWAP the labels at transit for the reverse path.

PE2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 400 node-id 4.4.4.4`	Configure global ID as 400 and node ID 4.4.4.4.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure interface eth1 as provider interface and interface local ID as 10.1.1.1.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 400 4.4.4.4`	Configure Tunnel with Tunnel ID 1 originating from this node PE1 (global ID 100 and node ID 1.1.1.) to destination at PE2 node (global ID 400 and node ID 4.4.4.4/
`(config-tnl)#tunnel-name tnl1`	Configure tunnel with name tnl1.
`(config-tnl)#tunnel-mode bidirectional`	Configure tunnel mode as bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 1003 eth1 pop`	Configure ILM entry for POP the label for forward path at egress.
`(config-bidir-tnl)#reverse-path nhlfe-entry 2001 eth1`	Configure NHFLE entry for PUSH the label for reverse path at egress.

Validation

PE1

```
PE1#show mpls-tp tunnel
<==============================================================================>
 Tunnel-id              : 1                Tunnel-Name          : tnl1
 Source Global-Id       : 100              Source Node-Id       : 1.1.1.1
 Destination Global-Id  : 400              Destination Node-Id  : 4.4.4.4
 Role   : Source                           Tunnel Index         : 1
 Mode   : COROUTED(bidirectional)          Tunnel State         : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001                Outgoing-Interface : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2003                Incoming-Interface  : eth1
       ILM-Index      : 1                   Cross-Connect-Index : 2
       Status : UP
<==============================================================================>
```

P1

```
P1#show mpls-tp tunnel
<==============================================================================>
 Tunnel-id              : 1                Tunnel-Name          : tnl1
 Source Global-Id       : 100              Source Node-Id       : 1.1.1.1
 Destination Global-Id  : 400              Destination Node-Id  : 4.4.4.4
 Role   : Transit                          Tunnel Index         : 1
 Mode   : COROUTED(bidirectional)          Tunnel State         : UP
```

```
      Forward-Path : ILM   <OPCODE : Swap>
        Incoming-Label : 1001              Incoming-Interface  : eth1
        ILM-Index      : 1                 Cross-Connect-Index : 1
        Outgoing-Label : 1002              Outgoing-Interface  : eth2
        NHLFE Index    : 1
        BW-class       : N/A
        Status : UP
      Reverse-Path : ILM   <OPCODE : Swap>
        Incoming-Label : 2002              Incoming-Interface  : eth2
        ILM-Index      : 2                 Cross-Connect-Index : 2
        Outgoing-Label : 2003              Outgoing-Interface  : eth1
        NHLFE Index    : 2
        BW-class       : N/A
        Status : UP
<==============================================================================>
```

P2

```
P2#show mpls-tp tunnel
<==============================================================================>
 Tunnel-id              : 1                Tunnel-Name          : tnl1
 Source Global-Id       : 100              Source Node-Id       : 1.1.1.1
 Destination Global-Id  : 400              Destination Node-Id  : 4.4.4.4
 Role   : Transit                          Tunnel Index         : 1
 Mode   : COROUTED(bidirectional)          Tunnel State         : UP


      Forward-Path : ILM   <OPCODE : Swap>
        Incoming-Label : 1002              Incoming-Interface  : eth1
        ILM-Index      : 1                 Cross-Connect-Index : 1
        Outgoing-Label : 1003              Outgoing-Interface  : eth2
        NHLFE Index    : 1
        BW-class       : N/A
        Status : UP
      Reverse-Path : ILM   <OPCODE : Swap>
        Incoming-Label : 2001              Incoming-Interface  : eth2
        ILM-Index      : 2                 Cross-Connect-Index : 2
        Outgoing-Label : 2002              Outgoing-Interface  : eth1
        NHLFE Index    : 2
        BW-class       : N/A
        Status : UP
<==============================================================================>
```

PE2

```
PE2#show mpls-tp tunnel
<==============================================================================>
 Tunnel-id              : 1                Tunnel-Name          : tnl1
 Source Global-Id       : 100              Source Node-Id       : 1.1.1.1
 Destination Global-Id  : 400              Destination Node-Id  : 4.4.4.4
 Role   : Destination                      Tunnel Index         : 1
 Mode   : COROUTED(bidirectional)          Tunnel State         : UP


      Forward-Path : ILM   <OPCODE : Pop>
        Incoming-Label : 1003              Incoming-Interface  : eth1
        ILM-Index      : 1                 Cross-Connect-Index : 1
        Status : UP
```



```
        Reverse-Path : NHLFE   <OPCODE : Push>
          Outgoing-Label : 2001                Outgoing-Interface : eth1
          NHLFE Index    : 2
          BW-class       : N/A
          Status : UP
     <============================================================================>
```

MEG Configuration for Tunnel

A co-routed bidirectional tunnel is used as the basis for this configuration; see Co-Routed Bi-Directional Tunnel in Chapter 21, *MPLS-TP Tunnel Configurations* for more information.

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-1`	Configure the MEG name as meg-1.
`(config-ietf-meg)#service type tunnel`	Configure service type as tunnel.
`(config-ietf-meg)#me me-1 tunnel`	Configure ME name as me-1.
`(config-ietf-me)#service tunnel tnl1`	Configure service tunnel tnl1 to be associated with the ME.

P1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-1`	Configure the MEG name as meg-1.
`(config-ietf-meg)#service type tunnel`	Configure service type as tunnel.
`(config-ietf-meg)#me me-1 tunnel`	Configure ME name as me-1.
`(config-ietf-me)#service tunnel tnl1`	Configure service tunnel tnl1 to be associated with the ME.

P2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-1`	Configure the MEG name as meg-1.
`(config-ietf-meg)#service type tunnel`	Configure service type as tunnel.
`(config-ietf-meg)#me me-1 tunnel`	Configure ME name as me-1.
`(config-ietf-me)#service tunnel tnl1`	Configure service tunnel tnl1 to be associated with the ME.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-1`	Configure the MEG name as meg-1.

`(config-ietf-meg)#service type tunnel`	Configure service type as tunnel.
`(config-ietf-meg)#me me-1 tunnel`	Configure ME name as me-1.
`(config-ietf-me)#service tunnel tnl1`	Configure service tunnel tnl1 to be associated with the ME.

Validation

PE1

```
PE1#show ietf meg brief

Total Number of MEGs configured : 1
================================================================================
Maintenance Entity Group  : meg-1              MEG Index    : 1
Service Type              : Tunnel             MP Location  : Per-node
----------------------------------------------------------------------------------
   Maintenance Entity     : me-1               ME Index     : 1
   Tunnel Name            : tnl1               MP Type      : MEP
   Oper Status            : UP
---------------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled


PE1#show ietf meg summary

Total Number of MEGs configured : 1
----------------------------------------------------------------------------------
MEG-Name             Service-Type    ME-Name             MP Type    Oper
Status
---------------------------------------------------------------------------------
meg-1                Tunnel          me-1                MEP        UP


P1P1#show ietf meg brief

Total Number of MEGs configured : 1
================================================================================
Maintenance Entity Group  : meg-1              MEG Index    : 1
Service Type              : Tunnel             MP Location  : Per-node
----------------------------------------------------------------------------------
   Maintenance Entity     : me-1               ME Index     : 1
   Tunnel Name            : tnl1               MP Type      : MIP
   Oper Status            : UP
      ----------------------------------------------------------------------------
-----
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled
```

```
P1#show ietf meg summary

Total Number of MEGs configured : 1
--------------------------------------------------------------------------------
---
MEG-Name             Service-Type    ME-Name              MP Type    Oper
Status
--------------------------------------------------------------------------------
---
meg-1                Tunnel          me-1                 MIP        UP
```

P2

```
P2#show ietf meg brief

Total Number of MEGs configured : 1
============================================================================
Maintenance Entity Group  : meg-1                MEG Index    : 1
Service Type              : Tunnel               MP Location  : Per-node
------------------------------------------------------------------------------
   Maintenance Entity     : me-1                 ME Index     : 1
   Tunnel Name            : tnl1                 MP Type      : MIP
   Oper Status            : UP
------------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled


P2#show ietf meg summary

Total Number of MEGs configured : 1
------------------------------------------------------------------------------
MEG-Name             Service-Type    ME-Name              MP Type    Oper
Status
------------------------------------------------------------------------------
meg-1                Tunnel          me-1                 MIP        UP
```

PE2

```
PE2#show ietf meg brief

Total Number of MEGs configured : 1
============================================================================
Maintenance Entity Group  : meg-1                MEG Index    : 1
Service Type              : Tunnel               MP Location  : Per-node
------------------------------------------------------------------------------
   Maintenance Entity     : me-1                 ME Index     : 1
   Tunnel Name            : tnl1                 MP Type      : MEP
   Oper Status            : UP
-----------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
```

```
        Lock                 : Disabled
        Fault-Management     : Disabled
        Loss-Measurement     : Disabled
        Delay-Measurement    : Disabled


  PE2#show ietf meg summary

  Total Number of MEGs configured : 1
  -------------------------------------------------------------------------------
  MEG-Name             Service-Type    ME-Name              MP Type    Oper
  Status
  -------------------------------------------------------------------------------
  meg-1                Tunnel          me-1                 MEP        UP
```

Fault Management Configuration for Tunnel

P1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-5`	Configure the MEG name as meg-5.
`(config-ietf-meg)#service type datalink`	Configure service type as datalink.
`(config-ietf-meg)#me me-5 datalink`	Configure ME name as me-5.
`(config-ietf-me)#service datalink eth2`	Configure the service datalink eth2 to be associated with the ME.
`(config-ietf-me)#fault-management`	Configure fault management (FM) on server layer at P1 (between P1 and P2) for tunnel tnl1.

P2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg-5`	Configure the MEG name as meg-5.
`(config-ietf-meg)#service type datalink`	Configure service type as datalink.
`(config-ietf-meg)#me me-5 datalink`	Configure ME name as me-5.
`(config-ietf-me)#service datalink eth1`	Configure the service datalink eth1 to be associated with the ME.
`(config-ietf-me)#fault-management`	Configure fault management (FM) on server layer at P2 (between P1 and P2) for tunnel tnl1.

Configure BFD for OAM Data Link MEG

P1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp bfd meg-name meg-5 me-name me-5`	Configure the BFD for OAM data link MEG.

P2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp bfd meg-name meg-5 me-name me-5`	Configure the BFD for OAM data link MEG.

Validation

P1

```
P1#show ietf meg meg-5 me me-5

=============================================================================
Maintenance Entity Group  : meg-5                 MEG Index    : 2
Service Type              : Datalink              MP Location  : Per-node
------------------------------------------------------------------------------
   Maintenance Entity     : me-5                  ME Index     : 1
   Provider Interface Name: eth2                  Interface Id : 20.1.1.2
   Oper Status            : UP
-----------------------------------------------------------------------------
      CC-CV               : Valid
      Fault-Management    : Valid (Refresh Interval: 20)


P1#show ietf meg brief

Total Number of MEGs configured : 2
=============================================================================
Maintenance Entity Group  : meg-1                 MEG Index    : 1
Service Type              : Tunnel                MP Location  : Per-node
------------------------------------------------------------------------------
   Maintenance Entity     : me-1                  ME Index     : 1
   Tunnel Name            : tnl1                  MP Type      : MIP
   Oper Status            : UP
-----------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled
```

```
================================================================================
Maintenance Entity Group  : meg-5                MEG Index    : 2
Service Type              : Datalink             MP Location  : Per-node
---------------------------------------------------------------------------------
   Maintenance Entity     : me-5                 ME Index     : 1
   Provider Interface Name: eth2                 Interface Id : 20.1.1.2
   Oper Status            : UP
--------------------------------------------------------------------------------
      CC-CV               : Enabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Enabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled


P1#show ietf meg summary

Total Number of MEGs configured : 2
---------------------------------------------------------------------------------
MEG-Name             Service-Type    ME-Name              MP Type    Oper
Status
---------------------------------------------------------------------------------
meg-1                Tunnel          me-1                 MIP        UP
meg-5                Datalink        me-5                 MEP        UP


P2#show ietf meg meg-5 me me-5

================================================================================
Maintenance Entity Group  : meg-5                MEG Index    : 2
Service Type              : Datalink             MP Location  : Per-node
---------------------------------------------------------------------------------
   Maintenance Entity     : me-5                 ME Index     : 1
   Provider Interface Name: eth1                 Interface Id : 20.1.1.1
   Oper Status            : UP
 --------------------------------------------------------------------------------
      CC-CV               : Valid
      Fault-Management    : Valid (Refresh Interval: 20)
```

P2

```
P2#show ietf meg brief

Total Number of MEGs configured : 2
================================================================================
Maintenance Entity Group  : meg-1                MEG Index    : 1
Service Type              : Tunnel               MP Location  : Per-node
---------------------------------------------------------------------------------
   Maintenance Entity     : me-1                 ME Index     : 1
   Tunnel Name            : tnl1                 MP Type      : MIP
   Oper Status            : UP
--------------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
```

```
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled

=============================================================================
Maintenance Entity Group  : meg-5              MEG Index    : 2
Service Type              : Datalink           MP Location  : Per-node
-------------------------------------------------------------------------------
--
   Maintenance Entity     : me-5               ME Index     : 1
   Provider Interface Name: eth1               Interface Id : 20.1.1.1
   Oper Status            : UP
------------------------------------------------------------------------------
      CC-CV               : Enabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Enabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled


P2#show ietf meg summary

Total Number of MEGs configured : 2
------------------------------------------------------------------------------
MEG-Name            Service-Type    ME-Name             MP Type    Oper
Status
-------------------------------------------------------------------------------
meg-1               Tunnel          me-1                MIP        UP
meg-5               Datalink        me-5                MEP        UP


P1#show bfd session
Sess-Idx   Remote-Disc  Lower-Layer  Sess-Type   Sess-State  UP-Time   Remote-
Addr
1          1            MPLS-TP      Single-Hop  Up          00:00:18
Number of Sessions:    1

P1#show bfd session detail
=====================================================

Session Index : 1
Lower Layer : MPLS-TP                    Version : 1
Session State : Up
Local Discriminator : 1                  Remote Discriminator : 1
MEG Name  : meg-5
ME Name   : me-5
Path Type : MPLS-TP Datalink
Options :

Diagnostics : None

Timers in Milliseconds :
Min Tx: 50                Min Rx: 50                Multiplier: 3
Neg Tx: 0                 Neg Rx: 0                 Neg detect mult: 3
Storage type : 2
Sess down time : 00:00:00
Sess discontinue time : 00:00:00
```

```
Bfd GTSM Disabled
Bfd Authentication Disabled

Counters values:
Pkt In : 0000000000000000                Pkt Out : 0000000000000000
UP Count : 0                             UPTIME : 00:00:20

Protocol Client Info:
----------------------------------------------------------
Number of Sessions:    1


P2#show bfd session
Sess-Idx   Remote-Disc  Lower-Layer  Sess-Type   Sess-State  UP-Time   Remote-
Addr
1          1            MPLS-TP      Single-Hop  Up          00:00:18
Number of Sessions:    1

P2
P2#show bfd session detail
======================================================

Session Index : 1
Lower Layer : MPLS-TP                    Version : 1
Session State : Up
Local Discriminator : 1                  Remote Discriminator : 1
MEG Name  : meg-5
ME Name   : me-5
Path Type : MPLS-TP Datalink
Options :

Diagnostics : None

Timers in Milliseconds :
Min Tx: 50               Min Rx: 50               Multiplier: 3
Neg Tx: 0                Neg Rx: 0                Neg detect mult: 3
Storage type : 2
Sess down time : 00:00:00
Sess discontinue time : 00:00:00
Bfd GTSM Disabled
Bfd Authentication Disabled

Counters values:
Pkt In : 0000000000000000                Pkt Out : 0000000000000000
UP Count : 0                             UPTIME : 00:00:20

Protocol Client Info:
----------------------------------------------------------
Number of Sessions:    1
```

How Fault Management Works

Bring down the physical interface which is connected to P2 (Transit) to create a fault on server layer.

Note: Both server layer nodes must be connected to the hub to receive fault messages when you are working with physical setup.

P1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#shutdown`	Bring down physical interface eth1 to create a fault on server layer.

Validation

P1

```
P1#show ip in brief
Interface              IP-Address       Status                Protocol
GMPLS Type
lo                     127.0.0.1        up                    up
MPLS
eth0                   10.12.20.195     up                    up
MPLS
eth2                   unassigned       administratively down down
data-control
eth1                   unassigned       up                    up
data-control
eth4                   unassigned       up                    up
MPLS
eth3                   unassigned       up                    up
MPLS
svlan0.1               unassigned       up                    down
MPLS

P1#show ietf meg brief

Total Number of MEGs configured : 2
=============================================================================
Maintenance Entity Group  : meg-1              MEG Index    : 1
Service Type              : Tunnel             MP Location  : Per-node
-----------------------------------------------------------------------------
   Maintenance Entity     : me-1               ME Index     : 1
   Tunnel Name            : tnl1               MP Type      : MIP
   Oper Status            : DOWN               Reason       : Path down
----------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled

=============================================================================
Maintenance Entity Group  : meg-5              MEG Index    : 2
Service Type              : Datalink           MP Location  : Per-node
-----------------------------------------------------------------------------
   Maintenance Entity     : me-5               ME Index     : 1
   Provider Interface Name: eth2               Interface Id : 20.1.1.3
   Oper Status            : DOWN               Reason       : Path down
-----------------------------------------------------------------------------
```

```
        CC-CV                : Enabled
        Loopback             : Disabled
        Lock                 : Disabled
        Fault-Management     : Enabled
        Loss-Measurement     : Disabled
        Delay-Measurement    : Disabled

  OAM Fault                  : Loss of Continuity


  P1#show bfd session
  Sess-Idx   Remote-Disc  Lower-Layer  Sess-Type   Sess-State  UP-Time   Remote-
  Addr
  1          1            MPLS-TP      Single-Hop  Down        00:00:00
  Number of Sessions:    1

  P1#show bfd session detail
  ======================================================

  Session Index : 1
  Lower Layer : MPLS-TP                         Version : 1
  Session State : Down
  Local Discriminator : 1                       Remote Discriminator : 1
  MEG Name  : meg-5
  ME Name   : me-5
  Path Type : MPLS-TP Datalink
  Options :

  Diagnostics : Control Detected Expiry

  Timers in Milliseconds :
  Min Tx: 50                 Min Rx: 50                 Multiplier: 3
  Neg Tx: 0                  Neg Rx: 0                  Neg detect mult: 3
  Storage type : 2
  Sess down time : 00:13:36
  Sess discontinue time : 00:00:00
  Bfd GTSM Disabled
  Bfd Authentication Disabled

  Counters values:
  Pkt In : 0000000000000000                     Pkt Out : 0000000000000000
  UP Count : 0                                  UPTIME : 00:00:00

  Protocol Client Info:
  ----------------------------------------------------------
  Number of Sessions:    1

  P1#show mpls-tp tunnel
  ==============================================================================>
   Tunnel-id              : 1                   Tunnel-Name          : tnl1
   Source Global-Id       : 100                 Source Node-Id       : 1.1.1.1
   Destination Global-Id : 400                  Destination Node-Id : 4.4.4.4
   Role  : Transit                              Tunnel Index         : 1
   Mode  : COROUTED(bidirectional)              Tunnel State         : Tunnel Down


       Forward-Path : ILM   <OPCODE : Swap>
```



```
          Incoming-Label : 1001              Incoming-Interface  : eth1
          ILM-Index      : 1                 Cross-Connect-Index : 1
          Outgoing-Label : 1002              Outgoing-Interface  : eth2
          NHLFE Index    : 1
          BW-class       : N/A
          Status : DOWN
        Reverse-Path : ILM   <OPCODE : Swap>
          Incoming-Label : 2002              Incoming-Interface  : eth2
          ILM-Index      : 2                 Cross-Connect-Index : 2
          Outgoing-Label : 2003              Outgoing-Interface  : eth1
          NHLFE Index    : 2
          BW-class       : N/A
          Status : DOWN
        ---------------------------------------------------------
         MEG Index       : 1              ME Index        : 1
        ---------------------------------------------------------
           Lock          : Disabled
           Loopback      : Disabled
=============================================================================>
```

P2

```
P2#show ip in brief
Interface             IP-Address      Status                Protocol
GMPLS Type
lo                    127.0.0.1       up                    up
MPLS
eth0                  10.12.20.196    up                    up
MPLS
eth3                  unassigned      up                    up
MPLS
eth4                  unassigned      up                    up
MPLS
eth1                  unassigned      up                    up
data-control
eth2                  unassigned      up                    up
data-control
svlan0.1              unassigned      up                    down
MPLS

P2#show mpls-tp tunnel
==============================================================================>
 Tunnel-id             : 1               Tunnel-Name          : tnl1
 Source Global-Id      : 100             Source Node-Id       : 1.1.1.1
 Destination Global-Id : 400             Destination Node-Id : 4.4.4.4
 Role  : Transit                         Tunnel Index         : 1
 Mode  : COROUTED(bidirectional)         Tunnel State         : UP


      Forward-Path : ILM   <OPCODE : Swap>
        Incoming-Label : 1002              Incoming-Interface  : eth1
        ILM-Index      : 1                 Cross-Connect-Index : 1
        Outgoing-Label : 1003              Outgoing-Interface  : eth2
        NHLFE Index    : 1
        BW-class       : N/A
        Status : UP
      Reverse-Path : ILM   <OPCODE : Swap>
        Incoming-Label : 2001              Incoming-Interface  : eth2
        ILM-Index      : 2                 Cross-Connect-Index : 2
```

```
          Outgoing-Label : 2002              Outgoing-Interface  : eth1
          NHLFE Index    : 2
          BW-class       : N/A
          Status : UP
        ---------------------------------------------------------
         MEG Index       : 1              ME Index        : 1
        ---------------------------------------------------------
           Lock          : Disabled
           Loopback      : Disabled
===============================================================================>

P2#show ietf meg brief

Total Number of MEGs configured : 2
==============================================================================
Maintenance Entity Group  : meg-1              MEG Index    : 1
Service Type              : Tunnel             MP Location  : Per-node
------------------------------------------------------------------------------
   Maintenance Entity     : me-1               ME Index     : 1
   Tunnel Name            : tnl1               MP Type      : MIP
   Oper Status            : DOWN               Reason       : Server Layer
Down
------------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled

==============================================================================
Maintenance Entity Group  : meg-5              MEG Index    : 2
Service Type              : Datalink           MP Location  : Per-node
------------------------------------------------------------------------------
   Maintenance Entity     : me-5               ME Index     : 1
   Provider Interface Name: eth1               Interface Id : 30.1.1.2
   Oper Status            : DOWN               Reason       : BFD detected
LOC
------------------------------------------------------------------------------
      CC-CV               : Enabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Enabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled

OAM Fault                 : Loss of Continuity


P2#show bfd session
Sess-Idx   Remote-Disc  Lower-Layer  Sess-Type   Sess-State  UP-Time   Remote-
Addr
1          1            MPLS-TP      Single-Hop  Down        00:00:00
Number of Sessions:    1

P2#show bfd session detail
======================================================
```



```
Session Index : 1
Lower Layer : MPLS-TP                      Version : 1
Session State : Down
Local Discriminator : 1                    Remote Discriminator : 1
MEG Name  : meg-5
ME Name   : me-5
Path Type : MPLS-TP Datalink
Options :

Diagnostics : Control Detected Expiry

Timers in Milliseconds :
Min Tx: 50               Min Rx: 50                 Multiplier: 3
Neg Tx: 0                Neg Rx: 0                  Neg detect mult: 3
Storage type : 2
Sess down time : 00:17:17
Sess discontinue time : 00:00:00
Bfd GTSM Disabled
Bfd Authentication Disabled

Counters values:
Pkt In : 0000000000000000                  Pkt Out : 0000000000000000
UP Count : 0                               UPTIME : 00:00:00

Protocol Client Info:
----------------------------------------------------------
Number of Sessions:    1

PE2#show ietf meg brief

Total Number of MEGs configured : 1
==============================================================================
Maintenance Entity Group  : meg-1               MEG Index    : 1
Service Type              : Tunnel              MP Location  : Per-node
------------------------------------------------------------------------------
   Maintenance Entity     : me-1                ME Index     : 1
   Tunnel Name            : tnl1                MP Type      : MEP
   Oper Status            : DOWN                Reason       : Received AIS FM
message
-----------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled

OAM Fault                 : Server Layer Down
```

CHAPTER 31 MPLS-TP Linear Protection Switching

This chapter contains configuration examples for the MPLS-TP Linear Protection Switching (LPS) feature.

Overview

The ZebOS-XP implementation of MPLS-TP LPS supports:

- Creation and management of protection groups that consist of primary and backup entities
- A Protection Switching Coordination (PSC) state machine
- Management of PSC events
- Primary and backup MPLS-TP tunnel management
- Management of native services, such as map-route and virtual circuits over MPLS-TP tunnels that are part of a protection domain

Topology

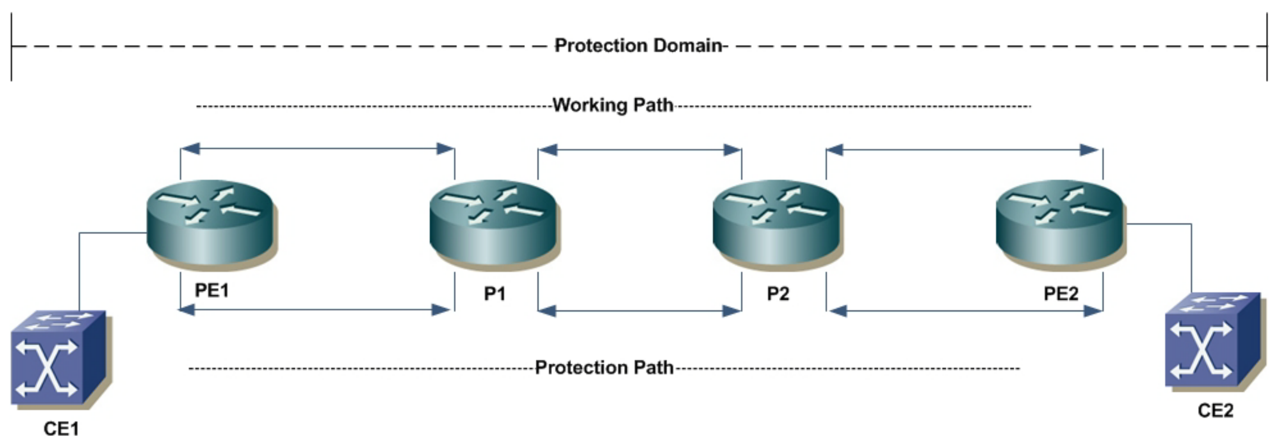


Figure 31-1: Bidirectional Tunnel

Primary Tunnel Path:

```
PE1(eth1)-------(e1)P1(e3)-----(e3)P2(e1)----(e1)PE2
```

Secondary Tunnel Path:

```
PE1(eth0)-------(e2)P1(e4)-----(e4)P2(e2)----(e2)PE2
```

Configuring LPS Using ITEF Identifiers

Co-Routed Bi-Directional Tunnel

PE1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 100 node-id 1.1.1.1`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1.
`(config)#interface eth0`	Enter interface mode for eth0.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 400 4.4.4.4`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name primary-tunnel`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path nhlfe-entry 1001 eth1`	Configure the NHFLE entry to push the label at ingress for the forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 2003 eth1 pop`	Configure the ILM entry to pop the label at ingress for the reverse path.
`(config)#mpls-tp tunnel 2 source 100 1.1.1.1 destination 400 4.4.4.4`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name backup-tunnel`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path nhlfe-entry 101 eth0`	Configure the NHLFE entry to push the label at ingress for the forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 203 eth0 pop`	Configure the ILM entry to pop the label at ingress for the reverse path.

P1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 200 node-id 2.2.2.2`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1.
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1.
`(config)#interface eth3`	Enter interface mode for eth3.

(config-if)#mpls-tp provider-interface 30.1.1.1	Configure the interface as a provider and set the local identifier to 30.1.1.1.
(config)#interface eth4	Enter interface mode for eth4.
(config-if)#mpls-tp provider-interface 40.1.1.1	Configure the interface as a provider and set the local identifier to 40.1.1.1.
(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 400 4.4.4.4	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name primary-tunnel	Set the tunnel name.
(config-tnl)#tunnel-mode bidirectional	Make the tunnel bidirectional.
(config-bidir-tnl)#forward-path ilm-entry 1001 eth1 swap 1002 eth3	Configure the ILM entry to swap the labels at transit for the forward path.
(config-bidir-tnl)#reverse-path ilm-entry 2002 eth3 swap 2003 eth1	Configure the ILM entry to swap the labels at transit for the reverse path.
(config)#mpls-tp tunnel 2 source 100 1.1.1.1 destination 400 4.4.4.4	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name backup-tunnel	Set the tunnel name.
(config-tnl)#tunnel-mode bidirectional	Make the tunnel bidirectional.
(config-bidir-tnl)#forward-path ilm-entry 101 eth2 swap 102 eth4	Configure the ILM entry to swap the labels at transit for the forward path.
(config-bidir-tnl)#reverse-path ilm-entry 202 eth4 swap 203 eth2	Configure the ILM entry to swap the labels at transit for the reverse path.

P2 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp global-id 300 node-id 3.3.3.3	Configure the global identifier and node identifier.
(config)#interface eth1	Enter interface mode for eth1.
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure the interface as a provider and set the local identifier to 10.1.1.1.
(config)#interface eth2	Enter interface mode for eth2.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure the interface as a provider and set the local identifier to 20.1.1.1.
(config)#interface eth3	Enter interface mode for eth3.
(config-if)#mpls-tp provider-interface 30.1.1.1	Configure the interface as a provider and set the local identifier to 30.1.1.1.
(config)#interface eth4	Enter interface mode for eth4.
(config-if)#mpls-tp provider-interface 40.1.1.1	Configure the interface as a provider and set the local identifier to 40.1.1.1.
(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 400 4.4.4.4	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-mode bidirectional	Make the tunnel bidirectional.
(config-tnl)#tunnel-name primary-tunnel	Set the tunnel name.
(config-bidir-tnl)#forward-path ilm-entry 1002 eth3 swap 1003 eth1	Configure the ILM entry to swap the labels at transit for the forward path.

`(config-bidir-tnl)#reverse-path ilm-entry 2001 eth1 swap 2002 eth3`	Configure the ILM entry to swap the labels at transit for the reverse path.
`(config)#mpls-tp tunnel 2 source 100 1.1.1.1 destination 400 4.4.4.4`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-tnl)#tunnel-name backup-tunnel`	Set the tunnel name.
`(config-bidir-tnl)#forward-path ilm-entry 102 eth4 swap 103 eth2`	Configure the ILM entry to swap the labels at transit for the forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 201 eth2 swap 202 eth4`	Configure the ILM entry to swap the labels at transit for the reverse path.

PE2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 400 node-id 4.4.4.4`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1.
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 400 4.4.4.4`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name primary-tunnel`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 1003 eth1 pop`	Configure the ILM entry to pop the label for the forward path at egress.
`(config-bidir-tnl)#reverse-path nhlfe-entry 2001 eth1`	Configure the NHLFE entry to push the label for the reverse path at egress
`(config)#mpls-tp tunnel 2 source 100 1.1.1.1 destination 400 4.4.4.4`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name backup-tunnel`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 103 eth2 pop`	Configure the ILM entry to pop the label for the forward path at egress.
`(config-bidir-tnl)#reverse-path nhlfe-entry 201 eth2`	Configure the NHLFE entry to push the label for the reverse path at egress.

Associated Bi-Directional Tunnel

These configurations are for an associated bidirectional tunnel. The figure below illustrates the topology.

Topology

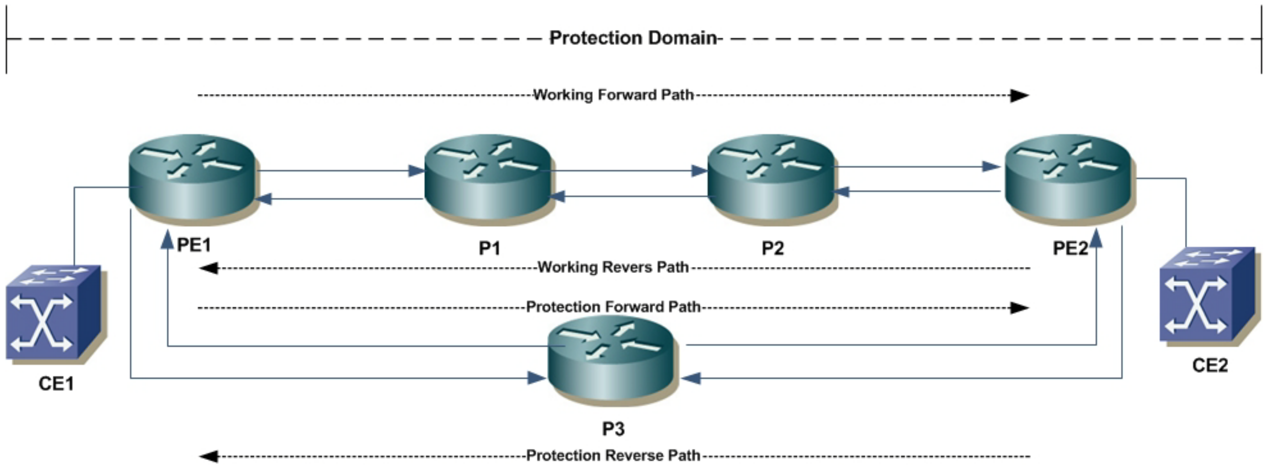


Figure 31-2: Associated Bidirectional Tunnel

Primary Forward Path:

```
PE1(eth1)-------(e1)P1(e3)-----(e3)P2(e1)----(e1)PE2(e6)
```

Primary Backup Path:

```
PE1(eth2)-------(e2)P1(e4)-----(e4)P2(e2)-----(e2)PE2
```

Backup Forward Path:

```
PE1 (eth3)-------(e4)P1(e2)----(e4)PE2
```

Backup Reverse Path:

```
PE1 (eth4)-------(e3)P1(e1)----(e3)PE2
```

PE1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 100 node-id 2.2.2.2`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1.
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1.
`(config)#interface eth3`	Enter interface mode for eth3.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as a provider and set the local identifier to 30.1.1.1.
`(config)#interface eth4`	Enter interface mode for eth4.
`(config-if)#mpls-tp provider-interface 40.1.1.1`	Configure the interface as a provider and set the local identifier to 40.1.1.1.

(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 200 5.5.5.5	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name primary-forward	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#nhlfe-entry 1001 eth1	Configure the NHFLE entry to push the label at ingress for the forward path.
(config)#mpls-tp tunnel 2 source 200 5.5.5.5 destination 100 1.1.1.1	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name primary-reverse	Configure tunnel name as primary-reverse.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#ilm-entry 2003 eth2 pop	Configure the ILM entry to pop the label at ingress for the reverse path.
(config)#mpls-tp associate fwd-tunnel primary-forward rev-tunnel primary-reverse	Associate the forward and reverse tunnels.
(config)#mpls-tp tunnel 3 source 100 1.1.1.1 destination 200 5.5.5.5	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name backup-forward	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#nhlfe-entry 3001 eth3	Configure the NHFLE entry to push the label at ingress for the forward path.
(config)#mpls-tp tunnel 4 source 200 5.5.5.5 destination 100 1.1.1.1	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name backup-reverse	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#ilm-entry 4002 eth4 pop	Configure the ILM entry to pop the label at ingress for the reverse path.
(config)#mpls-tp associate fwd-tunnel primary-forward rev-tunnel backup-reverse	Associate the forward and reverse tunnels.

P1 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp global-id 100 node-id 1.1.1.1	Configure the global identifier and node identifier
(config)#interface eth1	Enter interface mode for eth1.
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure the interface as a provider and set the local identifier to 10.1.1.1.
(config)#interface eth2	Enter interface mode for eth1.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure the interface as a provider and set the local identifier to 20.1.1.1.
(config)#interface eth3	Enter interface mode for eth3.
(config-if)#mpls-tp provider-interface 30.1.1.1	Configure the interface as a provider and set the local identifier to 30.1.1.1

`(config)#interface eth4`	Enter interface mode for eth4.
`(config-if)#mpls-tp provider-interface 40.1.1.1`	Configure the interface as a provider and set the local identifier to 40.1.1.1.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 200 5.5.5.5`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name primary-forward`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 1001 eth1 swap 1002 eth3`	Configure the ILM entry to swap the labels at transit for the forward path.
`(config)#mpls-tp tunnel 2 source 200 5.5.5.5 destination 100 1.1.1.1`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name primary-reverse`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 2002 eth4 swap 2003 eth2`	Configure the ILM entry to swap the labels at transit for the forward path.
`(config)#mpls-tp associate fwd-tunnel primary-forward rev-tunnel primary-reverse`	Associate the forward and reverse tunnel. Optional in transit node.

P2 (NSM)

`#configure terminal`	Enter configure mode.
`#mpls-tp global-id 100 node-id 3.3.3.3`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1.
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1.
`(config)#interface eth3`	Enter interface mode for eth3.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as a provider and set the local identifier to 30.1.1.1.
`(config)#interface eth4`	Enter interface mode for eth4.
`(config-if)#mpls-tp provider-interface 40.1.1.1`	Configure the interface as a provider and set the local identifier to 40.1.1.1.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 200 5.5.5.5`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name primary-forward`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 1002 eth3 swap 1003 eth1`	Configure the ILM entry to swap the labels at transit for the reverse path.

`(config)#mpls-tp tunnel 2 source 200 5.5.5.5 destination 100 1.1.1.1`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name primary-reverse`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 2001 eth2 swap 2002 eth4`	Configure the ILM entry to swap the labels at transit for the reverse path.
`(config)#mpls-tp associate fwd-tunnel primary-forward rev-tunnel primary-reverse`	Associate the forward and reverse tunnel. Optional for transit node.

P3 (NSM)

`#configure terminal`	Enter configure mode.
`#mpls-tp global-id 100 node-id 4.4.4.4`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1
`(config)#interface eth3`	Enter interface mode for eth3.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as a provider and set the local identifier to 30.1.1.1
`(config)#interface eth4`	Enter interface mode for eth4.
`(config-if)#mpls-tp provider-interface 40.1.1.1`	Configure the interface as a provider and set the local identifier to 40.1.1.1
`(config)#mpls-tp tunnel 3 source 100 1.1.1.1 destination 200 5.5.5.5`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name backup-forward`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 3001 eth4 swap 3002 eth2`	Configure the ILM entry to swap the labels at transit for the reverse path
`(config)#mpls-tp tunnel 4 source 200 5.5.5.5 destination 100 1.1.1.1`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name backup-reverse`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-undir-tnl)#ilm-entry 4001 eth1 swap 4002 eth3`	Configure the ILM entry to swap the labels at transit for the reverse path.
`(config)#mpls-tp associate fwd-tunnel primary-forward rev-tunnel backup-reverse`	Configure the ILM entry to swap the labels at transit for the reverse path.

PE2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 200 node-id 5.5.5.5`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1
`(config)#interface eth3`	Enter interface mode for eth3.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as a provider and set the local identifier to 30.1.1.1
`(config)#interface eth4`	Enter interface mode for eth4.
`(config-if)#mpls-tp provider-interface 40.1.1.1`	Configure the interface as a provider and set the local identifier to 40.1.1.1
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 200 5.5.5.5`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name primary-forward`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 1003 eth1 pop`	Configure the ILM entry to pop the label for the forward path at egress.
`(config)#mpls-tp tunnel 2 source 200 5.5.5.5 destination 100 1.1.1.1`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name primary-reverse`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#nhlfe-entry 2001 eth2`	Configure the NHFLE entry to push the label for the reverse path at egress.
`(config)#mpls-tp associate fwd-tunnel primary-reverse rev-tunnel primary-forward`	Associate the forward and reverse tunnels.
`mpls-tp tunnel 3 source 100 1.1.1.1 destination 200 5.5.5.5`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name backup-forward`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 3002 eth4 pop`	Configure the ILM entry to pop the label for the forward path at egress.
`(config)#mpls-tp tunnel 4 source 200 5.5.5.5 destination 100 1.1.1.1`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name backup-reverse`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.

`(config-unidir-tnl)#nhlfe-entry 4001 eth3`	Configure the NHFLE entry to push the label for the reverse path at egress.
`(config)#mpls-tp associate fwd-tunnel primary-reverse rev-tunnel backup-forward`	Associate the forward and reverse tunnels.

Configure MEG for LPS

In these examples, a bidirectional co-routed tunnel is the model.

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg1`	Configure the MEG name as meg1
`(config-ietf-meg)#me me1 tunnel`	Configure ME name as me1.
`(config-ietf-me)#service tunnel primary-tunnel`	Configure the primary-tunnel to associate with the ME
`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg2`	Configure the MEG name as meg2.
`(config-ietf-meg)#me me2 tunnel`	Configure ME name as me2.
`(config-ietf-me)#service tunnel backup-tunnel`	Configure the backup-tunnel to be associated with the ME.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg1`	Configure the MEG name as meg1.
`(config-ietf-meg)#me me1 tunnel`	Configure ME name as me1.
`(config-ietf-me)#service tunnel primary-tunnel`	Configure the primary-tunnel to be associated with the ME.
`#configure terminal`	Enter configure mode.
`(config)#ietf meg meg2`	Configure the MEG name as meg2.
`(config-ietf-meg)#me me2 tunnel`	Configure ME name as me2.
`(config-ietf-me)#service tunnel backup-tunnel`	Configure the backup-tunnel associate with the ME.

Validation

PE1

```
PE1#show ietf meg summary

Total Number of MEGs configured : 2
-------------------------------------------------------------------------------
MEG-Name              Service-Type    ME-Name               MP Type    Oper
Status
```

```
--------------------------------------------------------------------------------
meg1                 Tunnel         me1                 MEP        UP
meg2                 Tunnel         me2                 MEP        UP

PE1#showow ietf meg brief

Total Number of MEGs configured : 2
================================================================================
Maintenance Entity Group  : meg1                  MEG Index    : 1
Service Type              : Tunnel                MP Location  : Per-node
--------------------------------------------------------------------------------
   Maintenance Entity     : me1                   ME Index     : 1
   Tunnel Name            : primary-tunnel        MP Type      : MEP
   Oper Status            : UP
-------------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled
===============================================================================
Maintenance Entity Group  : meg2                  MEG Index    : 2
Service Type              : Tunnel                MP Location  : Per-node
--------------------------------------------------------------------------------
   Maintenance Entity     : me2                   ME Index     : 1
   Tunnel Name            : backup-tunnel         MP Type      : MEP
   Oper Status            : UP
------------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled


PE1#showow ietf meg meg1

================================================================================
Maintenance Entity Group  : meg1                  MEG Index    : 1
Service Type              : Tunnel                MP Location  : Per-node
--------------------------------------------------------------------------------
   Maintenance Entity     : me1                   ME Index     : 1
   Tunnel Name            : primary-tunnel        MP Type      : MEP
   Oper Status            : UP
-------------------------------------------------------------------------------

PE1#show ietf meg meg2

================================================================================
Maintenance Entity Group  : meg2                  MEG Index    : 2
Service Type              : Tunnel                MP Location  : Per-node
--------------------------------------------------------------------------------
   Maintenance Entity     : me2                   ME Index     : 1
   Tunnel Name            : backup-tunnel         MP Type      : MEP
   Oper Status            : UP
```

```
-----------------------------------------------------------------------------
```

PE2

```
#show ietf meg summary

Total Number of MEGs configured : 2
------------------------------------------------------------------------------
MEG-Name             Service-Type    ME-Name              MP Type    Oper
Status
------------------------------------------------------------------------------
meg1                 Tunnel          me1                  MEP        UP
meg2                 Tunnel          me2                  MEP        UP

#show ietf meg brief

Total Number of MEGs configured : 2
==============================================================================
Maintenance Entity Group  : meg1                MEG Index    : 1
Service Type              : Tunnel              MP Location  : Per-node
------------------------------------------------------------------------------
   Maintenance Entity     : me1                 ME Index     : 1
   Tunnel Name            : primary-tunnel      MP Type      : MEP
   Oper Status            : UP
-----------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled

=============================================================================
Maintenance Entity Group  : meg2                MEG Index    : 2
Service Type              : Tunnel              MP Location  : Per-node
------------------------------------------------------------------------------
   Maintenance Entity     : me2                 ME Index     : 1
   Tunnel Name            : backup-tunnel       MP Type      : MEP
   Oper Status            : UP
-----------------------------------------------------------------------------
      CC-CV               : Disabled
      Loopback            : Disabled
      Lock                : Disabled
      Fault-Management    : Disabled
      Loss-Measurement    : Disabled
      Delay-Measurement   : Disabled


#show ietf meg meg1

=============================================================================
Maintenance Entity Group  : meg1                MEG Index    : 1
Service Type              : Tunnel              MP Location  : Per-node
------------------------------------------------------------------------------
   Maintenance Entity     : me1                 ME Index     : 1
   Tunnel Name            : primary-tunnel      MP Type      : MEP
   Oper Status            : UP
--------------------------------------------------------------------------
```

```
#show ietf meg meg2

==================================================================================
Maintenance Entity Group   : meg2                  MEG Index    : 2
Service Type               : Tunnel                MP Location  : Per-node
----------------------------------------------------------------------------------
   Maintenance Entity      : me2                   ME Index     : 1
   Tunnel Name             : backup-tunnel         MP Type      : MEP
   Oper Status             : UP
-------------------------------------------------------------------------------
```

1:1 Co-Routed Bidirectional Linear Protection Switching

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp protection-group grp1`	Configure protection group as grp1.
`(config-pg)#primary meg meg1 me me1`	Configure primary MEG as meg1.
`(config-pg)#backup meg meg2 me me2`	Configure backup MEG as meg2.
`#configure terminal`	Enter configure mode.
`(config)#mpls-tp bfd meg-name meg1 me-name me1`	Configure BFD on primary MEG.
`(config)#mpls-tp bfd meg-name meg2 me-name me2`	Configure BFD on backup MEG.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp protection-group grp1`	Configure protection group as grp1
`(config-pg)#primary meg meg1 me me1`	Configure primary MEG as meg1.
`(config-pg)#backup meg meg2 me me2`	Configure backup meg as meg2.
`(config)#mpls-tp bfd meg-name meg1 me-name me1`	Configure BFD on primary MEG.
`(config)#mpls-tp bfd meg-name meg2 me-name me2`	Configure BFD on backup MEG.

Validation

PE1

```
PE1#sh mpls-tp protection-group
   <================================================================================>
    Group Name         : grp1             Oper Status         : Up
    Revertive mode     : Non-Revertive    Protection-scheme   : Bidirectional(1:1)
    WTR timer          : 300 sec          Hold-off timer      : 0 sec
    Rapid tx freq      : 3300 usec        Continual tx freq   : 5 sec
    Primary meg        : meg1             Backup meg          : meg2
    Primary me         : me1              Backup me           : me2
```

```
-------------------------------------------------------------------------------
 Current State     : Normal
 Reason            : -
 Current Event     : -
-------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx            : 133             Pkt-Rx            : 131
 Invalid pkt       : 0               Scheme mismatch   : 0
 Mode mismatch     : 0               Start time        : 00:11:17
*******************************************************************************
PE1#sh mpls-tp protection-group summary

Total Number of PS groups configured : 1
-------------------------------------------------------------------------------
Group-Name Primary-MegName Primary-MeName Backup-MegName Backup-MeName Oper-
Status
-------------------------------------------------------------------------------
grp1       meg1            me1            meg2           me2           UP


PE1#sh mpls-tp protection-group grp1
<=============================================================================>
 Group Name        : grp1            Oper Status       : Up
 Revertive mode    : Non-Revertive   Protection-scheme : Bidirectional(1:1)
 WTR timer         : 300 sec         Hold-off timer    : 0 sec
 Rapid tx freq     : 3300 usec       Continual tx freq : 5 sec
 Primary meg       : meg1            Backup meg        : meg2
 Primary me        : me1             Backup me         : me2
-------------------------------------------------------------------------------
 Current State     : Normal
 Reason            : -
 Current Event     : -
-------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx            : 137             Pkt-Rx            : 135
 Invalid pkt       : 0               Scheme mismatch   : 0
 Mode mismatch     : 0               Start time        : 00:11:36
*******************************************************************************
PE1#show mpls-tp tunnel
<=============================================================================>
 Tunnel-id              : 1            Tunnel-Name          : primary-tunnel
 Source Global-Id       : 100          Source Node-Id       : 1.1.1.1
 Destination Global-Id : 400           Destination Node-Id : 4.4.4.4
 Role  : Source                        Tunnel Index         : 1
 Mode  : COROUTED(bidirectional)       Tunnel State         : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001             Outgoing-Interface : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2003             Incoming-Interface  : eth1
       ILM-Index      : 5                Cross-Connect-Index : 2
       Status : UP
     ---------------------------------------------------------
```

```
      MEG Index       : 1             ME Index       : 1
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Primary
        PS State       : Normal
        Peer Tunnel-name: backup-tunnel
<==============================================================================>
<==============================================================================>
 Tunnel-id              : 2              Tunnel-Name          : backup-tunnel
 Source Global-Id       : 100            Source Node-Id       : 1.1.1.1
 Destination Global-Id  : 400            Destination Node-Id  : 4.4.4.4
 Role   : Source                         Tunnel Index         : 2
 Mode   : COROUTED(bidirectional)        Tunnel State         : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 101               Outgoing-Interface : eth0
       NHLFE Index    : 3
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 203               Incoming-Interface  : eth0
       ILM-Index      : 6                 Cross-Connect-Index : 4
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 2             ME Index       : 1
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Backup
        PS State       : Normal
        Peer Tunnel-name: primary-tunnel
<==============================================================================>
```

PE2

```
#show mpls-tp protection-group summary

Total Number of PS groups configured : 1
------------------------------------------------------------------------------
Group-Name       Primary-MegName  Primary-MeName   Backup-MegName   Backup-
MeName   Oper-Status
------------------------------------------------------------------------------
grp1            meg1            me1             meg2            me2
UP

#show mpls-tp protection-group summary ?
  |  Output modifiers
  >  Output redirection
  <cr>
```

```
#show mpls-tp protection-group grp1
<==============================================================================>
 Group Name         : grp1             Oper Status       : Up
 Revertive mode     : Non-Revertive    Protection-scheme : Bidirectional(1:1)
 WTR timer          : 300 sec          Hold-off timer    : 0 sec
 Rapid tx freq      : 3300 usec        Continual tx freq : 5 sec
 Primary meg        : meg1             Backup meg        : meg2
 Primary me         : me1              Backup me         : me2
--------------------------------------------------------------------------------
 Current State      : Normal
 Reason             : -
 Current Event      : -
-------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx             : 159              Pkt-Rx            : 160
 Invalid pkt        : 0                Scheme mismatch   : 0
 Mode mismatch      : 0                Start time        : 00:13:26
********************************************************************************
#show mpls-tp protection-group ?
  NAME     Protection-group name
  summary  summary
  |        Output modifiers
  >        Output redirection
  <cr>

#show mpls-tp protection-group
<==============================================================================>
 Group Name         : grp1             Oper Status       : Up
 Revertive mode     : Non-Revertive    Protection-scheme : Bidirectional(1:1)
 WTR timer          : 300 sec          Hold-off timer    : 0 sec
 Rapid tx freq      : 3300 usec        Continual tx freq : 5 sec
 Primary meg        : meg1             Backup meg        : meg2
 Primary me         : me1              Backup me         : me2
--------------------------------------------------------------------------------
 Current State      : Normal
 Reason             : -
 Current Event      : -
--------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx             : 163              Pkt-Rx            : 164
 Invalid pkt        : 0                Scheme mismatch   : 0
 Mode mismatch      : 0                Start time        : 00:13:44
********************************************************************************
#show mpls-tp tunnel
<==============================================================================>
 Tunnel-id              : 1                Tunnel-Name          : primary-tunnel
 Source Global-Id       : 100              Source Node-Id       : 1.1.1.1
 Destination Global-Id  : 400              Destination Node-Id  : 4.4.4.4
 Role   : Destination                      Tunnel Index         : 1
 Mode   : COROUTED(bidirectional)          Tunnel State         : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1003              Incoming-Interface  : eth1
       ILM-Index      : 3                 Cross-Connect-Index : 1
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
```

```
        Outgoing-Label : 2001            Outgoing-Interface : eth1
        NHLFE Index    : 2
        BW-class       : N/A
        Status : UP
      ---------------------------------------------------------
       MEG Index       : 1              ME Index        : 1
      ---------------------------------------------------------
         Lock          : Disabled
         Loopback      : Disabled
      ---------------------------------------------------------
        Protection Group Name  : grp1
      ---------------------------------------------------------
         PS Role        : Primary
         PS State       : Normal
         Peer Tunnel-name: backup-tunnel
 <==============================================================================
 =>
 <==============================================================================>
  Tunnel-id             : 2             Tunnel-Name         : backup-tunnel
  Source Global-Id      : 100           Source Node-Id      : 1.1.1.1
  Destination Global-Id : 400           Destination Node-Id : 4.4.4.4
  Role  : Destination                   Tunnel Index        : 2
  Mode  : COROUTED(bidirectional)       Tunnel State        : UP


      Forward-Path : ILM   <OPCODE : Pop>
        Incoming-Label : 103             Incoming-Interface  : eth2
        ILM-Index      : 4               Cross-Connect-Index : 3
        Status : UP
      Reverse-Path : NHLFE   <OPCODE : Push>
        Outgoing-Label : 201             Outgoing-Interface : eth2
        NHLFE Index    : 4
        BW-class       : N/A
        Status : UP
      ---------------------------------------------------------
       MEG Index       : 2              ME Index        : 1
      ---------------------------------------------------------
         Lock          : Disabled
         Loopback      : Disabled
      ---------------------------------------------------------
        Protection Group Name  : grp1
      ---------------------------------------------------------
         PS Role        : Backup
         PS State       : Normal
         Peer Tunnel-name: primary-tunnel
 <==============================================================================>
```

1+1 Co-Routed Bi-Directional Linear Protection Switching

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp protection-group grp1`	Configure protection group as grp1.
`(config-pg)#primary meg meg1 me me1`	Configure primary meg as meg1.
`(config-pg)#backup meg meg2 me me2`	Configure backup meg as meg2.
`(config-pg)#protection-scheme bidirectional permanent`	Configure protection scheme as bidirectional 1+1.
`(config)#mpls-tp bfd meg-name meg1 me-name me1`	Configure BFD on primary MEG.
`(config)#mpls-tp bfd meg-name meg2 me-name me2`	Configure BFD on backup MEG.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp protection-group grp1`	Configure protection group as grp1.
`(config-pg)#primary meg meg1 me me1`	Configure primary MEG as meg1.
`(config-pg)#backup meg meg2 me me2`	Configure backup MEG as meg2.
`(config-pg)#protection-scheme bidirectional permanent`	Configure protection scheme as bidirectional 1+1.
`(config)#mpls-tp bfd meg-name meg1 me-name me1`	Configure BFD on primary MEG.
`(config)#mpls-tp bfd meg-name meg2 me-name me2`	Configure BFD on backup MEG.

Validation

PE1

```
PE1#show mpls-tp protection-group
<==============================================================================>
 Group Name          : grp1             Oper Status         : Up
 Revertive mode      : Non-Revertive    Protection-scheme : Bidirectional(1+1)
 WTR timer           : 300 sec          Hold-off timer      : 0 sec
 Rapid tx freq       : 3300 usec        Continual tx freq : 5 sec
 Primary meg         : meg1             Backup meg          : meg2
 Primary me          : me1              Backup me           : me2
-------------------------------------------------------------------------------
-
 Current State       : Normal
 Reason              : -
 Current Event       : -
-------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx              : 181              Pkt-Rx              : 179
```

```
 Invalid pkt       : 0                 Scheme mismatch   : 3
 Mode mismatch     : 0                 Start time        : 00:15:10
******************************************************************************
PE1#show mpls-tp protection-group grp1
<============================================================================>
 Group Name        : grp1              Oper Status       : Up
 Revertive mode    : Non-Revertive     Protection-scheme : Bidirectional(1+1)
 WTR timer         : 300 sec           Hold-off timer    : 0 sec
 Rapid tx freq     : 3300 usec         Continual tx freq : 5 sec
 Primary meg       : meg1              Backup meg        : meg2
 Primary me        : me1               Backup me         : me2
------------------------------------------------------------------------------
 Current State     : Normal
 Reason            : -
 Current Event     : -
------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx            : 182               Pkt-Rx            : 180
 Invalid pkt       : 0                 Scheme mismatch   : 3
 Mode mismatch     : 0                 Start time        : 00:15:16
******************************************************************************
PE1#show mpls-tp protection-group summary

Total Number of PS groups configured : 1
------------------------------------------------------------------------------
Group-Name       Primary-MegName  Primary-MeName   Backup-MegName   Backup-
MeName   Oper-Status
------------------------------------------------------------------------------
grp1            meg1            me1             meg2            me2
UP

PE1#show mpls-tp tunnel
<============================================================================>
 Tunnel-id             : 1             Tunnel-Name           : primary-tunnel
 Source Global-Id      : 100           Source Node-Id        : 1.1.1.1
 Destination Global-Id : 400           Destination Node-Id   : 4.4.4.4
 Role  : Source                        Tunnel Index          : 1
 Mode  : COROUTED(bidirectional)       Tunnel State          : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001             Outgoing-Interface : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2003             Incoming-Interface  : eth1
       ILM-Index      : 5                Cross-Connect-Index : 2
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 1             ME Index        : 1
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
```

```
        PS Role        : Primary
        PS State       : Normal
        Peer Tunnel-name: backup-tunnel
<==============================================================================>
<==============================================================================>
 Tunnel-id              : 2               Tunnel-Name          : backup-tunnel
 Source Global-Id       : 100             Source Node-Id       : 1.1.1.1
 Destination Global-Id  : 400             Destination Node-Id  : 4.4.4.4
 Role   : Source                          Tunnel Index         : 2
 Mode   : COROUTED(bidirectional)         Tunnel State         : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 101               Outgoing-Interface : eth0
       NHLFE Index    : 3
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 203               Incoming-Interface  : eth0
       ILM-Index      : 6                 Cross-Connect-Index : 4
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 2             ME Index        : 1
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Backup
        PS State       : Normal
        Peer Tunnel-name: primary-tunnel
<==============================================================================>
```

PE2

```
#show mpls-tp protection-group
<==============================================================================>
 Group Name         : grp1             Oper Status          : Up
 Revertive mode     : Non-Revertive    Protection-scheme : Bidirectional(1+1)
 WTR timer          : 300 sec          Hold-off timer       : 0 sec
 Rapid tx freq      : 3300 usec        Continual tx freq : 5 sec
 Primary meg        : meg1             Backup meg           : meg2
 Primary me         : me1              Backup me            : me2
--------------------------------------------------------------------------------
 Current State      : Normal
 Reason             : -
 Current Event      : -
--------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx             : 192              Pkt-Rx               : 192
 Invalid pkt        : 0                Scheme mismatch      : 3
 Mode mismatch      : 0                Start time           : 00:16:06
********************************************************************************
#show mpls-tp protection-group summary

Total Number of PS groups configured : 1
```

```
-----------------------------------------------------------------------------
Group-Name       Primary-MegName  Primary-MeName   Backup-MegName   Backup-
MeName   Oper-Status
------------------------------------------------------------------------------
grp1            meg1            me1             meg2            me2
UP

#show mpls-tp protection-group grp1
<============================================================================>
 Group Name         : grp1              Oper Status       : Up
 Revertive mode     : Non-Revertive     Protection-scheme : Bidirectional(1+1)
 WTR timer          : 300 sec           Hold-off timer    : 0 sec
 Rapid tx freq      : 3300 usec         Continual tx freq : 5 sec
 Primary meg        : meg1              Backup meg        : meg2
 Primary me         : me1               Backup me         : me2
------------------------------------------------------------------------------
 Current State      : Normal
 Reason             : -
 Current Event      : -
------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx             : 193               Pkt-Rx            : 194
 Invalid pkt        : 0                 Scheme mismatch   : 3
 Mode mismatch      : 0                 Start time        : 00:16:12
******************************************************************************
#show mpls-tp tunnel
<============================================================================>
 Tunnel-id             : 1              Tunnel-Name         : primary-tunnel
 Source Global-Id      : 100            Source Node-Id      : 1.1.1.1
 Destination Global-Id : 400            Destination Node-Id : 4.4.4.4
 Role  : Destination                    Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)        Tunnel State        : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1003             Incoming-Interface  : eth1
       ILM-Index      : 3                Cross-Connect-Index : 1
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2001             Outgoing-Interface : eth1
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 1              ME Index        : 1
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Primary
        PS State       : Normal
        Peer Tunnel-name: backup-tunnel
<============================================================================>
<============================================================================>
 Tunnel-id             : 2              Tunnel-Name         : backup-tunnel
```

```
    Source Global-Id      : 100            Source Node-Id      : 1.1.1.1
    Destination Global-Id : 400            Destination Node-Id : 4.4.4.4
    Role   : Destination                   Tunnel Index        : 2
    Mode   : COROUTED(bidirectional)       Tunnel State        : UP


        Forward-Path : ILM   <OPCODE : Pop>
          Incoming-Label : 103                Incoming-Interface   : eth2
          ILM-Index      : 4                  Cross-Connect-Index : 3
          Status : UP
        Reverse-Path : NHLFE   <OPCODE : Push>
          Outgoing-Label : 201                Outgoing-Interface : eth2
          NHLFE Index    : 4
          BW-class       : N/A
          Status : UP
        ---------------------------------------------------------
         MEG Index       : 2             ME Index        : 1
        ---------------------------------------------------------
           Lock          : Disabled
           Loopback      : Disabled
        ---------------------------------------------------------
          Protection Group Name  : grp1
        ---------------------------------------------------------
           PS Role        : Backup
           PS State       : Normal
           Peer Tunnel-name: primary-tunnel
   <==============================================================================>
```

1+1 Associated Unidirectional Linear Protection Switching

This scheme is valid only for Associated tunnels. Please refer to the associated tunnel configuration in the tunnel configuration section.

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp protection-group grp1`	Configure protection group as grp1.
`(config-pg)#primary meg meg1 me me1`	Configure primary MEG as meg1. For an associated tunnel, the forward tunnel is always configured as a primary MEG.
`(config-pg)#backup meg meg3 me me3`	Configure backup MEG as meg3. For an associated tunnel, the reverse tunnel is always configured as a backup MEG.
`(config-pg)#protection-scheme unidirectional permanent`	Configure protection scheme as unidirectional 1+1.
`#configure terminal`	Enter configure mode.
`(config)#mpls-tp bfd meg-name meg1 me-name me1 min-tx 100 min-rx 0`	Configure independent monitoring for unidirectional protection scheme.
`(config)#mpls-tp bfd meg-name meg3 me-name me3 min-tx 100 min-rx 0`	Configure independent monitoring for unidirectional protection scheme.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp protection-group grp1`	Configure protection group as grp1
`(config-pg)#primary meg meg2 me me2`	Configure primary meg as meg2. Configure primary MEG as meg1. For an associated tunnel, the forward tunnel is always configured as a primary MEG.
`(config-pg)#backup meg meg4 me me4`	Configure backup MEG as meg4. For an associated tunnel, the reverse tunnel is always configured as a backup MEG.
`(config-pg)#protection-scheme unidirectional permanent`	Configure protection scheme as unidirectional 1+1.
`#configure terminal`	Enter configure mode.
`(config)#mpls-tp bfd meg-name meg1 me-name me1 min-tx 0 min-rx 100`	Configure independent monitoring for unidirectional protection scheme.
`(config)#mpls-tp bfd meg-name meg3 me-name me3 min-tx 0 min-rx 100`	Configure independent monitoring for unidirectional protection scheme.

Validation

PE1

```
#show mpls-tp protection-group
<=============================================================================>
 Group Name         : grp1              Oper Status        : Up
 Revertive mode     : Non-Revertive     Protection-scheme  : Unidirectional(1+1)
 WTR timer          : 300 sec           Hold-off timer     : 0 sec
 Rapid tx freq      : 3300 usec         Continual tx freq  : 5 sec
 Primary meg        : meg1              Backup meg         : meg3
 Primary me         : me1               Backup me          : me3
-------------------------------------------------------------------------------
 Current State      : Normal
 Reason             : -
 Current Event      : -
-------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx             : 5                 Pkt-Rx             : 2
 Invalid pkt        : 0                 Scheme mismatch    : 0
 Mode mismatch      : 0                 Start time         : 00:00:34

#show mpls-tp protection-group grp1
<=============================================================================>
 Group Name         : grp1              Oper Status        : Up
 Revertive mode     : Non-Revertive     Protection-scheme  : Unidirectional(1+1)
 WTR timer          : 300 sec           Hold-off timer     : 0 sec
 Rapid tx freq      : 3300 usec         Continual tx freq  : 5 sec
 Primary meg        : meg1              Backup meg         : meg3
 Primary me         : me1               Backup me          : me3
-------------------------------------------------------------------------------
 Current State      : Normal
 Reason             : -
 Current Event      : -
```



```
------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx            : 9                 Pkt-Rx            : 6
 Invalid pkt       : 0                 Scheme mismatch   : 0
 Mode mismatch     : 0                 Start time        : 00:00:57
******************************************************************************
#show mpls-tp protection-group summary

Total Number of PS groups configured : 1
------------------------------------------------------------------------------
---------------------
Group-Name       Primary-MegName  Primary-MeName   Backup-MegName   Backup-
MeName   Oper-Status
------------------------------------------------------------------------------
grp1            meg1            me1             meg3            me3
UP

#show mpls-tp protection-group
<============================================================================>
 Group Name        : grp1              Oper Status       : Up
 Revertive mode    : Non-Revertive     Protection-scheme : Unidirectional(1+1)
 WTR timer         : 300 sec           Hold-off timer    : 0 sec
 Rapid tx freq     : 3300 usec         Continual tx freq : 5 sec
 Primary meg       : meg1              Backup meg        : meg3
 Primary me        : me1               Backup me         : me3
------------------------------------------------------------------------------
 Current State     : Normal
 Reason            : -
 Current Event     : -
------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx            : 11                Pkt-Rx            : 8
 Invalid pkt       : 0                 Scheme mismatch   : 0
 Mode mismatch     : 0                 Start time        : 00:01:03
******************************************************************************
#show mpls-tp tunnel
<============================================================================>
 Tunnel-id              : 3                Tunnel-Name           : backup-forward
 Source Global-Id       : 100              Source Node-Id        : 1.1.1.1
 Destination Global-Id  : 200              Destination Node-Id   : 5.5.5.5
 Role  : Source                            Tunnel Index          : 1
 Mode  : ASSOCIATED(unidirectional)        Tunnel State          : UP
 Associated-Tunnel   : backup-reverse

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 3001              Outgoing-Interface : eth3
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 1             ME Index        : 1
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
```



```
        PS Role        : Backup
        PS State       : Normal
        Peer Tunnel-name: primary-forward
    <==============================================================================>
    <==============================================================================>
     Tunnel-id             : 1            Tunnel-Name         : primary-forward
     Source Global-Id      : 100          Source Node-Id      : 1.1.1.1
     Destination Global-Id : 200          Destination Node-Id : 5.5.5.5
     Role  : Source                       Tunnel Index        : 2
     Mode  : ASSOCIATED(unidirectional)   Tunnel State        : UP
     Associated-Tunnel   : primary-reverse

         Forward-Path : NHLFE   <OPCODE : Push>
           Outgoing-Label : 1001            Outgoing-Interface : eth1
           NHLFE Index    : 2
           BW-class       : N/A
           Status : UP
         ---------------------------------------------------------
          MEG Index       : 2             ME Index        : 1
         ---------------------------------------------------------
            Lock          : Disabled
            Loopback      : Disabled
         ---------------------------------------------------------
           Protection Group Name  : grp1
         ---------------------------------------------------------
            PS Role        : Primary
            PS State       : Normal
            Peer Tunnel-name: backup-forward
    <==============================================================================>
    <==============================================================================>
     Tunnel-id             : 5            Tunnel-Name         : uni
     Source Global-Id      : 100          Source Node-Id      : 1.1.1.1
     Destination Global-Id : 200          Destination Node-Id : 5.5.5.5
     Role  : Source                       Tunnel Index        : 3
     Mode  : UNIDIRECTIONAL               Tunnel State        : UP


         Forward-Path : NHLFE   <OPCODE : Push>
           Outgoing-Label : 1001            Outgoing-Interface : eth1
           NHLFE Index    : 2
           BW-class       : N/A
           Status : UP
         ---------------------------------------------------------
          MEG Index       : 6             ME Index        : 1
         ---------------------------------------------------------
            Lock          : Disabled
            Loopback      : Disabled
    <==============================================================================>
    <==============================================================================>
     Tunnel-id             : 2            Tunnel-Name         : primary-reverse
     Source Global-Id      : 200          Source Node-Id      : 5.5.5.5
     Destination Global-Id : 100          Destination Node-Id : 1.1.1.1
     Role  : Destination                  Tunnel Index        : 4
     Mode  : ASSOCIATED(unidirectional)   Tunnel State        : UP
     Associated-Tunnel   : primary-forward

         Reverse-Path : ILM   <OPCODE : Pop>
```

```
      Incoming-Label : 2003             Incoming-Interface  : eth0
      ILM-Index      : 1                Cross-Connect-Index : 3
      Status : UP
    ---------------------------------------------------------
     MEG Index       : 4             ME Index        : 1
    ---------------------------------------------------------
       Lock          : Disabled
       Loopback      : Disabled
    ---------------------------------------------------------
      Protection Group Name  : grp1
    ---------------------------------------------------------
       PS Role        : Primary
       PS State       : Normal
       Peer Tunnel-name: backup-reverse
<==============================================================================>
<==============================================================================>
 Tunnel-id              : 4             Tunnel-Name          : backup-reverse
 Source Global-Id       : 200           Source Node-Id       : 5.5.5.5
 Destination Global-Id : 100            Destination Node-Id : 1.1.1.1
 Role  : Destination                    Tunnel Index         : 5
 Mode  : ASSOCIATED(unidirectional)     Tunnel State         : UP
 Associated-Tunnel   : backup-forward

     Reverse-Path : ILM   <OPCODE : Pop>
      Incoming-Label : 4002             Incoming-Interface  : eth4
      ILM-Index      : 2                Cross-Connect-Index : 4
      Status : UP
    ---------------------------------------------------------
     MEG Index       : 5             ME Index        : 1
    ---------------------------------------------------------
       Lock          : Disabled
       Loopback      : Disabled
    ---------------------------------------------------------
      Protection Group Name  : grp1
    ---------------------------------------------------------
       PS Role        : Backup
       PS State       : Normal
       Peer Tunnel-name: primary-reverse
<==============================================================================>
```

PE2

```
PE2#show mpls-tp protection-group
<==============================================================================>
 Group Name          : grp1             Oper Status         : Up
 Revertive mode      : Non-Revertive    Protection-scheme : Unidirectional(1+1)
 WTR timer           : 300 sec          Hold-off timer      : 0 sec
 Rapid tx freq       : 3300 usec        Continual tx freq : 5 sec
 Primary meg         : meg2             Backup meg          : meg4
 Primary me          : me2              Backup me           : me4
--------------------------------------------------------------------------------
 Current State       : Normal
 Reason              : -
 Current Event       : -
--------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx              : 2                Pkt-Rx              : 2
```



```
 Invalid pkt        : 0                  Scheme mismatch    : 1
 Mode mismatch      : 0                  Start time         : 00:00:11
******************************************************************************
Pe2#show mpls-tp protection-group grp1
<=============================================================================>
 Group Name         : grp1               Oper Status        : Up
 Revertive mode     : Non-Revertive      Protection-scheme : Unidirectional(1+1)
 WTR timer          : 300 sec            Hold-off timer     : 0 sec
 Rapid tx freq      : 3300 usec          Continual tx freq : 5 sec
 Primary meg        : meg2               Backup meg         : meg4
 Primary me         : me2                Backup me          : me4
------------------------------------------------------------------------------
 Current State      : Normal
 Reason             : -
 Current Event      : -
------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx             : 15                 Pkt-Rx             : 16
 Invalid pkt        : 0                  Scheme mismatch    : 1
 Mode mismatch      : 0                  Start time         : 00:01:25
******************************************************************************
Pe2#show mpls-tp protection-group summary

Total Number of PS groups configured : 1
------------------------------------------------------------------------------
Group-Name       Primary-MegName  Primary-MeName   Backup-MegName   Backup-
MeName   Oper-Status
------------------------------------------------------------------------------
grp1            meg2            me2             meg4            me4
UP

Pe2#show mpls-tp tunnel
<=============================================================================>
 Tunnel-id              : 2               Tunnel-Name            : primary-reverse
 Source Global-Id       : 200             Source Node-Id         : 5.5.5.5
 Destination Global-Id : 100              Destination Node-Id : 1.1.1.1
 Role   : Source                          Tunnel Index           : 1
 Mode   : ASSOCIATED(unidirectional)      Tunnel State           : UP
 Associated-Tunnel     : primary-forward

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2001              Outgoing-Interface : eth2
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 1              ME Index        : 1
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Primary
        PS State       : Normal
        Peer Tunnel-name: backup-reverse
<=============================================================================>
```

```
<============================================================================>
 Tunnel-id             : 4              Tunnel-Name          : backup-reverse
 Source Global-Id      : 200            Source Node-Id       : 5.5.5.5
 Destination Global-Id : 100            Destination Node-Id : 1.1.1.1
 Role  : Source                         Tunnel Index         : 2
 Mode  : ASSOCIATED(unidirectional)     Tunnel State         : UP
 Associated-Tunnel   : backup-forward

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 4001             Outgoing-Interface : eth3
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 4             ME Index        : 1
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Backup
        PS State       : Normal
        Peer Tunnel-name: primary-reverse
<============================================================================>
<============================================================================>
 Tunnel-id             : 1              Tunnel-Name          : primary-forward
 Source Global-Id      : 100            Source Node-Id       : 1.1.1.1
 Destination Global-Id : 200            Destination Node-Id : 5.5.5.5
 Role  : Destination                    Tunnel Index         : 3
 Mode  : ASSOCIATED(unidirectional)     Tunnel State         : UP
 Associated-Tunnel   : primary-reverse

     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1003             Incoming-Interface  : eth1
       ILM-Index      : 1                Cross-Connect-Index : 3
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 2             ME Index        : 1
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Primary
        PS State       : Normal
        Peer Tunnel-name: backup-forward
<============================================================================>
 Tunnel-id             : 3              Tunnel-Name          : backup-forward
 Source Global-Id      : 100            Source Node-Id       : 1.1.1.1
 Destination Global-Id : 200            Destination Node-Id : 5.5.5.5
 Role  : Destination                    Tunnel Index         : 4
 Mode  : ASSOCIATED(unidirectional)     Tunnel State         : UP
 Associated-Tunnel   : backup-reverse
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 3002             Incoming-Interface  : eth4
```



```
      ILM-Index       : 2                 Cross-Connect-Index : 4
      Status : UP
    ---------------------------------------------------------
     MEG Index        : 3              ME Index         : 1
    ---------------------------------------------------------
       Lock           : Disabled
       Loopback       : Disabled
    ---------------------------------------------------------
      Protection Group Name   : grp1
    ---------------------------------------------------------
       PS Role         : Backup
       PS State        : Normal
       Peer Tunnel-name: primary-forward
<==============================================================================>
```

Configuring LPS Using ITU-T Identifiers

Co-Routed Bi-Directional Tunnel

Refer to Figure 31-1 on page 363 for the topology.

PE1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 1.1.1.1`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1.
`(config)#interface eth0`	Enter interface mode for eth0.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1
`(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier and the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name primary-tunnel`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path nhlfe- entry 1001 eth1`	Configure the NHFLE entry to push the label at ingress for the forward path.
`(config-bidir-tnl)#reverse-path ilm- entry 2003 eth1 pop`	Configure the ILM entry to pop the label at ingress for the reverse path.
`(config)#mpls-tp tunnel 2 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier and the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name backup-tunnel`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.

`(config-bidir-tnl)#forward-path nhlfe- entry 101 eth0`	Configure the NHLFE entry to push the label at ingress for the forward path.
`(config-bidir-tnl)#reverse-path ilm- entry 203 eth0 pop`	Configure the ILM entry to pop the label at ingress for the reverse path.

P1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 2.2.2.2`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1.
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1.
`(config)#interface eth3`	Enter interface mode for eth3.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as a provider and set the local identifier to 30.1.1.1.
`(config)#interface eth4`	Enter interface mode for eth4.
`(config-if)#mpls-tp provider-interface 40.1.1.1`	Configure the interface as a provider and set the local identifier to 40.1.1.1.
`(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name primary-tunnel`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm- entry 1001 eth1 swap 1002 eth3`	Configure the ILM entry to swap the labels at transit for the forward path.
`(config-bidir-tnl)#reverse-path ilm- entry 2002 eth3 swap 2003 eth1`	Configure the ILM entry to swap the labels at transit for the reverse path.
`(config)#mpls-tp tunnel 2 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name backup-tunnel`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm- entry 101 eth2 swap 102 eth4`	Configure the ILM entry to swap the labels at transit for the forward path.
`(config-bidir-tnl)#reverse-path ilm- entry 202 eth4 swap 203 eth2`	Configure the ILM entry to swap the labels at transit for the reverse path.

P2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 3.3.3.3`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.

`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1.
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1.
`(config)#interface eth3`	Enter interface mode for eth3.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as a provider and set the local identifier to 30.1.1.1.
`(config)#interface eth4`	Enter interface mode for eth4.
`(config-if)#mpls-tp provider-interface 40.1.1.1`	Configure the interface as a provider and set the local identifier to 40.1.1.1.
`(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-tnl)#tunnel-name primary-tunnel`	Set the tunnel name.
`(config-bidir-tnl)#forward-path ilm- entry 1002 eth3 swap 1003 eth1`	Configure the ILM entry to swap the labels at transit for the forward path.
`(config-bidir-tnl)#reverse-path ilm- entry 2001 eth1 swap 2002 eth3`	Configure the ILM entry to swap the labels at transit for the reverse path.
`(config)#mpls-tp tunnel 2 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-tnl)#tunnel-name backup-tunnel`	Set the tunnel name.
`(config-bidir-tnl)#forward-path ilm- entry 102 eth4 swap 103 eth2`	Configure the ILM entry to swap the labels at transit for the forward path.
`(config-bidir-tnl)#reverse-path ilm- entry 201 eth2 swap 202 eth4`	Configure the ILM entry to swap the labels at transit for the reverse path.

PE2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 4.4.4.4`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1.
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1.
`(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name primary-tunnel`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm- entry 1003 eth1 pop`	Configure the ILM entry to pop the label for the forward path at egress.

`(config-bidir-tnl)#reverse-path nhlfe- entry 2001 eth1`	Configure the NHLFE entry to push the label for the reverse path at egress
`(config)#mpls-tp tunnel 2 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name backup-tunnel`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm- entry 103 eth2 pop`	Configure the ILM entry to pop the label for the forward path at egress.
`(config-bidir-tnl)#reverse-path nhlfe- entry 201 eth2`	Configure the NHLFE entry to push the label for the reverse path at egress.

Validation

```
PE1#sh mpls-tp tunnel
<================================================================================>
 Tunnel-id             : 1               Tunnel-Name         : primary-tunnel
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Source                          Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)         Tunnel State        : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001              Outgoing-Interface : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2003              Incoming-Interface  : eth1
       ILM-Index      : 1                 Cross-Connect-Index : 2
       Status : UP
<================================================================================>
<================================================================================>
 Tunnel-id             : 2               Tunnel-Name         : backup-tunnel
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Source                          Tunnel Index        : 2
 Mode  : COROUTED(bidirectional)         Tunnel State        : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 101               Outgoing-Interface : eth0
       NHLFE Index    : 3
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 203               Incoming-Interface  : eth0
       ILM-Index      : 2                 Cross-Connect-Index : 4
       Status : UP
<================================================================================>
```



```
P1#sh mpls-tp tunnel
<===============================================================================>
 Tunnel-id             : 1               Tunnel-Name         : primary-tunnel
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Transit                         Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)         Tunnel State        : UP


     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1001              Incoming-Interface  : eth1
       ILM-Index      : 1                 Cross-Connect-Index : 1
       Outgoing-Label : 1002              Outgoing-Interface  : eth3
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 2002              Incoming-Interface  : eth3
       ILM-Index      : 2                 Cross-Connect-Index : 2
       Outgoing-Label : 2003              Outgoing-Interface  : eth1
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
<===============================================================================>
<===============================================================================>
 Tunnel-id             : 2               Tunnel-Name         : backup-tunnel
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Transit                         Tunnel Index        : 2
 Mode  : COROUTED(bidirectional)         Tunnel State        : UP


     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 101               Incoming-Interface  : eth2
       ILM-Index      : 3                 Cross-Connect-Index : 3
       Outgoing-Label : 102               Outgoing-Interface  : eth4
       NHLFE Index    : 3
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 202               Incoming-Interface  : eth4
       ILM-Index      : 4                 Cross-Connect-Index : 4
       Outgoing-Label : 203               Outgoing-Interface  : eth2
       NHLFE Index    : 4
       BW-class       : N/A
       Status : UP
<===============================================================================>

P2#sh mpls-tp tunnel
```

```
<==============================================================================>
 Tunnel-id             : 1               Tunnel-Name         : primary-tunnel
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Transit                         Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)         Tunnel State        : UP


     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1002              Incoming-Interface  : eth3
       ILM-Index      : 1                 Cross-Connect-Index : 1
       Outgoing-Label : 1003              Outgoing-Interface  : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 2001              Incoming-Interface  : eth1
       ILM-Index      : 2                 Cross-Connect-Index : 2
       Outgoing-Label : 2002              Outgoing-Interface  : eth3
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
<==============================================================================>
<==============================================================================>
 Tunnel-id             : 2               Tunnel-Name         : backup-tunnel
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Transit                         Tunnel Index        : 2
 Mode  : COROUTED(bidirectional)         Tunnel State        : UP


     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 102               Incoming-Interface  : eth4
       ILM-Index      : 3                 Cross-Connect-Index : 3
       Outgoing-Label : 103               Outgoing-Interface  : eth2
       NHLFE Index    : 3
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 201               Incoming-Interface  : eth2
       ILM-Index      : 4                 Cross-Connect-Index : 4
       Outgoing-Label : 202               Outgoing-Interface  : eth4
       NHLFE Index    : 4
       BW-class       : N/A
       Status : UP
<==============================================================================>

PE2#sh mpls-tp tunnel
<==============================================================================>
 Tunnel-id             : 1               Tunnel-Name         : primary-tunnel
```



```
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Destination                     Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)         Tunnel State        : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1003              Incoming-Interface  : eth1
       ILM-Index      : 1                 Cross-Connect-Index : 1
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2001              Outgoing-Interface : eth1
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
<===============================================================================>
<===============================================================================>
 Tunnel-id             : 2               Tunnel-Name         : backup-tunnel
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Destination                     Tunnel Index        : 2
 Mode  : COROUTED(bidirectional)         Tunnel State        : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 103               Incoming-Interface  : eth2
       ILM-Index      : 2                 Cross-Connect-Index : 3
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 201               Outgoing-Interface : eth2
       NHLFE Index    : 4
       BW-class       : N/A
       Status : UP
<===============================================================================>
```

Associated Bi-Directional Tunnel

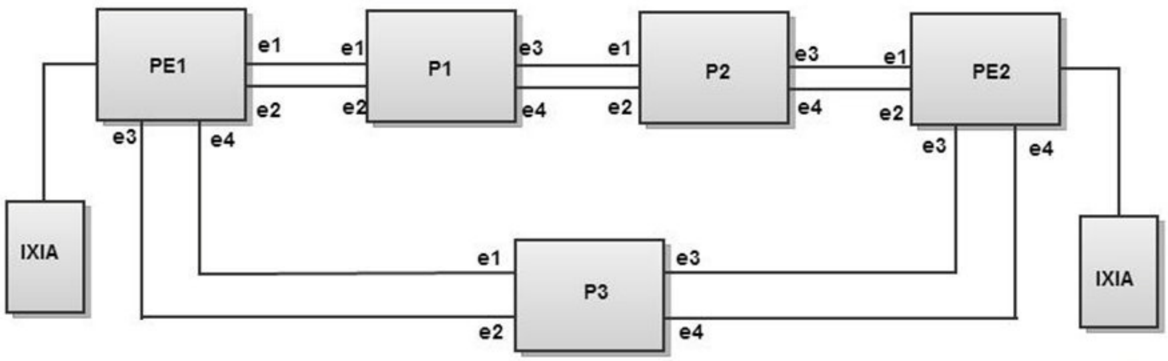


Figure 31-3: Topology

PE1 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 1.1.1.1`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1
`(config)#interface eth3`	Enter interface mode for eth3.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as a provider and set the local identifier to 30.1.1.1
`(config)#interface eth4`	Enter interface mode for eth4.
`(config-if)#mpls-tp provider-interface 40.1.1.1`	Configure the interface as a provider and set the local identifier to 40.1.1.1
`(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name primary-forward`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Configure tunnel mode unidirectional.
`(config-unidir-tnl)#nhlfe-entry 1001 eth1`	Configure the NHLFE entry to push the label at ingress for the forward path.
`(config)#mpls-tp tunnel 2 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name primary-reverse`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Configure tunnel mode unidirectional.

(config-unidir-tnl)#ilm-entry 3002 eth4 pop	Configure the ILM entry to pop the label at ingress for the reverse path.
(config)#mpls-tp associate fwd-tunnel primary-forward rev-tunnel primary-reverse	Associate the forward and reverse tunnels.
(config)#mpls-tp tunnel 3 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
(config-tnl)#tunnel-name backup-forward	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#nhlfe-entry 2001 eth2	Configure the NHLFE entry to push the label at ingress for the forward path
(config)#mpls-tp tunnel 4 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
(config-tnl)#tunnel-name backup-reverse	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Make the tunnel unidirectional.
(config-unidir-tnl)#ilm-entry 4002 eth3 pop	Configure the ILM entry to pop the label at ingress for the reverse path.
(config)#mpls-tp associate fwd-tunnel backup-forward rev-tunnel backup-reverse	Associate the forward and reverse tunnels.

P1 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp itut cc IN icc AIRTEL node-id 2.2.2.2	Configure the country code, carrier code, and node identifier.
(config)#interface eth1	Enter interface mode for eth1.
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure the interface as a provider and set the local identifier to 10.1.1.1
(config)#interface eth2	Enter interface mode for eth1.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure the interface as a provider and set the local identifier to 20.1.1.1
(config)#interface eth3	Enter interface mode for eth3.
(config-if)#mpls-tp provider-interface 30.1.1.1	Configure the interface as a provider and set the local identifier to 30.1.1.1
(config)#interface eth4	Enter interface mode for eth4.
(config-if)#mpls-tp provider-interface 40.1.1.1	Configure the interface as a provider and set the local identifier to 40.1.1.1
(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
(config)#tunnel-name primary-forward	Set the tunnel name.
(config-tnl)#tunnel-mode unidirectional	Configure tunnel mode as unidirectional.
(config-unidir-tnl)#ilm-entry 1001 eth1 swap 1002 eth3	Configure the ILM entry to swap the labels at transit for the forward path.
(config)#mpls-tp tunnel 3 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
(config-tnl)#tunnel-name backup-forward	Set the tunnel name.

`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 2001 eth2 swap 2002 eth4`	Configure the ILM entry to swap the labels at transit for the forward path.

P2 (NSM)

`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1
`(config)#interface eth3`	Enter interface mode for eth3.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as a provider and set the local identifier to 30.1.1.1
`(config)#interface eth4`	Enter interface mode for eth4.
`(config-if)#mpls-tp provider-interface 40.1.1.1`	Configure the interface as a provider and set the local identifier to 40.1.1.1
`#configure terminal`	Enter configure mode.
`#mpls-tp itut cc IN icc AIRTEL node-id 3.3.3.3`	Configure the country code, carrier code, and node identifier.
`(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name primary-forward`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidire-tnl)#ilm-entry 1002 eth1 swap 1003 eth3`	Configure the ILM entry to swap the labels at transit for the reverse path.
`(config)#mpls-tp tunnel 3 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name backup-forward`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 2002 eth2 swap 2003 eth4`	Configure the ILM entry to swap the labels at transit for the reverse path.

P3 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 5.5.5.5`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1
`(config)#interface eth3`	Enter interface mode for eth3.

`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as a provider and set the local identifier to 30.1.1.1
`(config)#interface eth4`	Enter interface mode for eth4.
`(config-if)#mpls-tp provider-interface 40.1.1.1`	Configure the interface as a provider and set the local identifier to 40.1.1.1
`(config)#mpls-tp tunnel 2 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name primary-reverse`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidr-tnl)#ilm-entry 3001 eth3 swap 3002 eth1`	Configure the ILM entry to swap the labels at transit for the reverse path.
`(config)#mpls-tp tunnel 4 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name backup-reverse`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-undir-tnl)#ilm-entry 4001 eth4 swap 4002 eth2`	Configure the ILM entry to swap the labels at transit for the reverse path.

PE2 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 4.4.4.4`	Configure the country code, carrier code, and node identifier.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as a provider and set the local identifier to 10.1.1.1
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as a provider and set the local identifier to 20.1.1.1
`(config)#interface eth3`	Enter interface mode for eth3.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as a provider and set the local identifier to 30.1.1.1
`(config)#interface eth4`	Enter interface mode for eth4.
`(config-if)#mpls-tp provider-interface 40.1.1.1`	Configure the interface as a provider and set the local identifier to 40.1.1.1
`(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name primary-forward`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 1003 eth1 pop`	Configure the ILM entry to pop the label for the forward path at egress.
`(config)#mpls-tp tunnel 2 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name primary-reverse`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.

`(config-unidir-tnl)#nhlfe-entry 3001 eth3`	Configure the NHLFE entry to push the label for the reverse path at egress.
`(config)#mpls-tp associate fwd-tunnel primary-reverse rev-tunnel primary-forward`	Associate the forward and reverse tunnels.
`(config)#mpls-tp tunnel 3 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 4.4.4.4`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name backup-forward`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#ilm-entry 2003 eth2 pop`	Configure the ILM entry to pop the label for the forward path at egress.
`(config)#mpls-tp tunnel 4 source IN AIRTEL 4.4.4.4 destination IN AIRTEL 1.1.1.1`	Configure the tunnel identifier as well as the country code, carrier code, and node identifier for the source and destination.
`(config-tnl)#tunnel-name backup-reverse`	Set the tunnel name.
`(config-tnl)#tunnel-mode unidirectional`	Make the tunnel unidirectional.
`(config-unidir-tnl)#nhlfe-entry 4001 eth4`	Configure the NHLFE entry to push the label for the reverse path at egress.
`(config)#mpls-tp associate fwd-tunnel backup-reverse rev-tunnel backup-forward`	Associate the forward and reverse tunnels.

MEG for Co-Routed Tunnel

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#itut meg meg1`	Configure the meg name as meg1.
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel.
`(config-itut-meg)#mep-id 1`	Configure the MEP identifier as 1.
`(config-itut-mp)#service tunnel primary-tunnel`	Configure the service tunnel primary-tunnel to be associated with the ME.
`(config-itut-mp)#continuity-check interval 4`	Configure the continuity check with interval 4.
`(config-itut-mp)#rmep-id 2 cc IN icc BSNL umc meg2`	Configure the remote MEP.
`(config)#itut meg meg3`	Configure the meg name as meg3.
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel.
`(config-itut-meg)#mep-id 1`	Configure the MEP identifier as 1
`(config-itut-mp)#service tunnel backup-tunnel`	Configure the service tunnel backup-tunnel to be associated with the ME.
`(config-itut-mp)#continuity-check interval 4`	Configure the continuity check with interval 4.
`(config-itut-mp)#rmep-id 4 cc IN icc BSNL umc meg4`	Configure the remote MEP.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#itut meg meg2`	Configure the MEG name as meg2.
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel.
`(config-itut-meg)#mep-id 2`	Configure the MEP identifier as 2.
`(config-itut-mp)#service tunnel primary-tunnel`	Configure the service tunnel primary-tunnel to be associated with the ME.
`(config-itut-mp)#continuity-check interval 4`	Configure the continuity check with interval 4.
`(config-itut-mp)#rmep-id 1 cc IN icc BSNL umc meg1`	Configure the remote MEP.
`(config)#itut meg meg4`	Configure the meg name as meg4.
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel.
`(config-itut-meg)#mep-id 4`	Configure the MEP identifier as 4.
`(config-itut-mp)#service tunnel backup-tunnel`	Configure the service tunnel backup-tunnel to be associated with the ME.
`(config-itut-mp)#continuity-check interval 4`	Configure the continuity check with interval 4.
`(config-itut-mp)#rmep-id 1 cc IN icc BSNL umc meg3`	Configure the remote MEP.

Validation

```
PE1#sh itut meg brief

==================================================================================
Maintenance Entity Group  : INAIRTEL/meg1       MEG Index    : 1
Service Type              : Tunnel              MEG Level    : 7
   -------------------------------------------------------------------------------
   MP-ID                  : 1                   MP Type      : MEP
   Tunnel Name            : primary-tunnel      Oper Status  : UP
   RMEP                   : INBSNL/meg2,2

   -------------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 4)
==================================================================================
Maintenance Entity Group  : INAIRTEL/meg3       MEG Index    : 2
Service Type              : Tunnel              MEG Level    : 7
   -------------------------------------------------------------------------------
   MP-ID                  : 1                   MP Type      : MEP
   Tunnel Name            : backup-tunnel       Oper Status  : UP
   RMEP                   : INBSNL/meg4,4

   -------------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 4)
```

```
PE1#sh mpls-tp cc summary

Total number of CC sessions configured : 2

---------------------------------------------------------------------------------
MEG-Name             MP-Id           CCM-Interval         Oper status
---------------------------------------------------------------------------------
INAIRTEL/meg1        1               4                    Up
INAIRTEL/meg3        1               4                    Up

PE2#sh itut meg brief

===================================================================================
Maintenance Entity Group  : INAIRTEL/meg2       MEG Index    : 1
Service Type              : Tunnel              MEG Level    : 7
   --------------------------------------------------------------------------------
   MP-ID                  : 2                   MP Type      : MEP
   Tunnel Name            : primary-tunnel      Oper Status  : UP
   RMEP                   : INBSNL/meg1,1

   --------------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 4)
===================================================================================
Maintenance Entity Group  : INAIRTEL/meg4       MEG Index    : 2
Service Type              : Tunnel              MEG Level    : 7
   --------------------------------------------------------------------------------
   MP-ID                  : 4                   MP Type      : MEP
   Tunnel Name            : backup-tunnel       Oper Status  : UP
   RMEP                   : INBSNL/meg3,1

   --------------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 4)

PE2#sh mpls-tp cc summary

Total number of CC sessions configured : 2

---------------------------------------------------------------------------------
MEG-Name             MP-Id           CCM-Interval         Oper status
---------------------------------------------------------------------------------
INAIRTEL/meg2        2               4                    Up
INAIRTEL/meg4        4               4                    Up
```


MEG for Associated Tunnel

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-p`	Configure the MEG name as meg-p.
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel.
`(config-itut-meg)#mep-id 1`	Configure MEP ID as 1.
`(config-itut-mp)#service tunnel primary-forward`	Configure primary-tunnel to be associated with the MEP.
`(config-itut-mp)#continuity-check interval 4`	Enable continuity check and set the continuity check interval to 1 second.
`(config-itut-mp)#rmep-id 4 cc IN icc AIRTEL umc meg-p`	Configure remote MEP-ID (PE2).
`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-b`	Configure the MEG name as meg-b.
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel
`(config-itut-meg)#mep-id 1`	Configure MEP ID as 1
`(config-itut-mp)#service tunnel backup-forward`	Configure backup-tunnel to be associated with the MEP.
`(config-itut-mp)#rmep-id 4 cc IN icc AIRTEL umc meg-b`	Configure the remote MEP.
`(config-itut-mp)#continuity-check interval 4s`	Enable continuity check and set the continuity check interval to 1 second.
`#configure terminal`	Enter configure mode.
`(config)#itut meg megpr`	Configure the MEG name as megpr.
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel.
`(config-itut-meg)#mep-id 11`	Configure the MEP ID as 11.
`(config-ietf-mp)#service tunnel primary-reverse`	Configure backup-tunnel to be associated with the MEP.
`(config-ietf-mp)#rmep-id 44 cc IN icc AIRTEL umc megpr`	Configure remote MEP-ID (PE2).
`#configure terminal`	Enter configure mode.
`(config)#itut meg megbr`	Configure the MEG name as megbr.
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel.
`(config-itut-meg)#mep-id 11`	Configure MEP ID as 11
`(config-ietf-mp)#service tunnel backup-reverse`	Configure backup-tunnel to be associated with the MEP.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-p`	Configure the MEG name as megp.
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel.
`(config-itut-meg)#mep-id 4`	Configure MEP ID as 4.
`(config-itut-mp)#service tunnel primary-reverse`	Configure primary-tunnel to be associated with the MEP.
`(config-itut-mp)#rmep-id 1 cc IN icc AIRTEL umc meg-p`	Configure the remote MEP.
`(config-itut-mp)#continuity-check interval 4s`	Enable continuity check and set the continuity check interval to 1 second.
`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-b`	Configure the MEG name as meg-b.
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel
`(config-itut-meg)#mep-id 4`	Configure the MEP identifier as 4.
`(config-itut-mp)#service tunnel backup-reverse`	Configure primary-tunnel to be associated with the MEP.
`(config-itut-mp)#rmep-id 1 cc IN icc AIRTEL umc meg-b`	Configure the remote MEP.
`(config-itut-mp)#continuity-check interval 4`	Enable continuity check and set the continuity check interval to 1 second.
`#configure terminal`	Enter configure mode.
`(config)#itut meg megpr`	Configure the MEG name as megpr.
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel.
`(config-itut-meg)#mep-id 44`	Configure the MEP identifier as 44.
`(config-itut-mp)#service tunnel primary-forward`	Configure primary-tunnel to be associated with the MEP.
`#configure terminal`	Enter configure mode.
`(config)#itut meg megbr`	Configure the MEG name as megbr.
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel.
`(config-itut-meg)#mep-id 44`	Configure the MEP identifier as 44.
`(config-itut-mp)#service tunnel backup-forward`	Configure primary-tunnel to be associated with the MEP.

Validation

```
PE1#show meg summary
---------------------------------MEG-TYPE : IETF---------------------------------------
MEG-Name              Service-Type    ME-Name              MP Type    Oper-Status

---------------------------------MEG-TYPE : ITUT---------------------------------------
MEG-Name             Service-Type    MEG-Level          MP-ID      MP Type        Oper-
Status
INAIRTEL/meg-p        Tunnel           7                  1          MEP            UP
INAIRTEL/meg-b        Tunnel           7                  1          MEP            UP
INAIRTEL/megpr       Tunnel           7                 11         MEP           DOWN
```

```
INAIRTEL/megbr       Tunnel          7                  11         MEP           DOWN

-----------------------------------------------------------------------------------------

PE1#show itut meg brief

====================================================================================
Maintenance Entity Group  : INAIRTEL/meg-p      MEG Index    : 1
Service Type              : Tunnel              MEG Level    : 7
   ---------------------------------------------------------------------------------
   MP-ID                  : 1                   MP Type      : MEP
   Tunnel Name            : primary-forward     Oper Status  : UP
   RMEP                   : INAIRTEL/meg-p,4

   ---------------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 4)
====================================================================================
Maintenance Entity Group  : INAIRTEL/meg-b      MEG Index    : 2
Service Type              : Tunnel              MEG Level    : 7
   ---------------------------------------------------------------------------------
   MP-ID                  : 1                   MP Type      : MEP
   Tunnel Name            : backup-forward      Oper Status  : UP
   RMEP                   : INAIRTEL/meg-b,4

   ---------------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 4)
====================================================================================
Maintenance Entity Group  : INAIRTEL/megpr      MEG Index    : 3
Service Type              : Tunnel              MEG Level    : 7
   ---------------------------------------------------------------------------------
   MP-ID                  : 11                  MP Type      : MEP
   Tunnel Name            : primary-reverse     Oper Status  : DOWN
   Reason                 : Association not allowed on destination
   RMEP                   : INAIRTEL/megpr,44

   ---------------------------------------------------------------------------------
====================================================================================
Maintenance Entity Group  : INAIRTEL/megbr      MEG Index    : 4
Service Type              : Tunnel              MEG Level    : 7
   ---------------------------------------------------------------------------------
   MP-ID                  : 11                  MP Type      : MEP
   Tunnel Name            : backup-reverse      Oper Status  : DOWN
   Reason                 : Association not allowed on destination
   ---------------------------------------------------------------------------------

PE1#show mpls-tp cc summary

Total number of CC sessions configured : 2

---------------------------------------------------------------------------------
```

```
MEG-Name             MP-Id           CCM-Interval         Oper status
---------------------------------------------------------------------------------
INAIRTEL/meg-p       1               4                    Up
INAIRTEL/meg-b       1               4                    Up

PE1#show mpls-tp cc meg meg-p

   MEG-Name               : INAIRTEL/meg-p
   MP-Id                  : 1

   Oper status            : Up

   CCM-Interval           : 4
   Lowest alarm priority  : 1
   FNG alarm time         : 2.5 seconds
   FNG reset time         : 10 seconds

   All RMEPs are dead     : False
   RDI present            : False

   Fault identified       : False

   RMEP-Id                : 4
   RMEG-Name              : INAIRTEL/meg-p
   RMEP CCM defect        : False
   RMEP last RDI          : False

PE1#show mpls-tp cc meg meg-b

   MEG-Name               : INAIRTEL/meg-b
   MP-Id                  : 1

   Oper status            : Up

   CCM-Interval           : 4
   Lowest alarm priority  : 1
   FNG alarm time         : 2.5 seconds
   FNG reset time         : 10 seconds

   All RMEPs are dead     : False
   RDI present            : False

   Fault identified       : False

   RMEP-Id                : 4
   RMEG-Name              : INAIRTEL/meg-b
   RMEP CCM defect        : False
   RMEP last RDI          : False
```

PE2:

```
PE2#show meg summary
---------------------------------MEG-TYPE : IETF---------------------------------------
MEG-Name             Service-Type    ME-Name              MP Type    Oper-Status

---------------------------------MEG-TYPE : ITUT---------------------------------------
MEG-Name            Service-Type    MEG-Level           MP-ID      MP Type         Oper-
Status
INAIRTEL/meg-p       Tunnel           7                   4           MEP             UP
INAIRTEL/meg-b       Tunnel           7                   4           MEP             UP
INAIRTEL/megpr      Tunnel          7                   44         MEP            DOWN
INAIRTEL/megbr      Tunnel          7                   44         MEP            DOWN

---------------------------------------------------------------------------------------


PE2#show itut meg brief

==================================================================================
Maintenance Entity Group  : INAIRTEL/meg-p      MEG Index    : 1
Service Type              : Tunnel              MEG Level    : 7
   -------------------------------------------------------------------------------
   MP-ID                  : 4                   MP Type      : MEP
   Tunnel Name            : primary-reverse     Oper Status  : UP
   RMEP                   : INAIRTEL/meg-p,1

   -------------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 4)
==================================================================================
Maintenance Entity Group  : INAIRTEL/meg-b      MEG Index    : 2
Service Type              : Tunnel              MEG Level    : 7
   -------------------------------------------------------------------------------
   MP-ID                  : 4                   MP Type      : MEP
   Tunnel Name            : backup-reverse      Oper Status  : UP
   RMEP                   : INAIRTEL/meg-b,1

   -------------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 4)
==================================================================================
Maintenance Entity Group  : INAIRTEL/megpr      MEG Index    : 3
Service Type              : Tunnel              MEG Level    : 7
   -------------------------------------------------------------------------------
   MP-ID                  : 44                  MP Type      : MEP
   Tunnel Name            : primary-forward     Oper Status  : DOWN
   Reason                 : Association not allowed on destination
   -------------------------------------------------------------------------------
==================================================================================
Maintenance Entity Group  : INAIRTEL/megbr      MEG Index    : 4
Service Type              : Tunnel              MEG Level    : 7
   -------------------------------------------------------------------------------
```

```
   MP-ID                  : 44                    MP Type      : MEP
   Tunnel Name            : backup-forward      Oper Status  : DOWN
   Reason                 : Association not allowed on destination
   --------------------------------------------------------------------------------

PE2#show mpls-tp cc summary

Total number of CC sessions configured : 2

---------------------------------------------------------------------------------
MEG-Name              MP-Id           CCM-Interval         Oper status
---------------------------------------------------------------------------------
INAIRTEL/meg-p        4               4                    Up
INAIRTEL/meg-b        4               4                    Up

PE2#show mpls-tp cc meg meg-p

   MEG-Name               : INAIRTEL/meg-p
   MP-Id                  : 4

   Oper status            : Up

   CCM-Interval           : 4
   Lowest alarm priority  : 1
   FNG alarm time         : 2.5 seconds
   FNG reset time         : 10 seconds

   All RMEPs are dead     : False
   RDI present            : False

   Fault identified       : False

   RMEP-Id                : 1
   RMEG-Name              : INAIRTEL/meg-p
   RMEP CCM defect        : False
   RMEP last RDI          : False

PE2#show mpls-tp cc meg meg-b

   MEG-Name               : INAIRTEL/meg-b
   MP-Id                  : 4

   Oper status            : Up

   CCM-Interval           : 4
   Lowest alarm priority  : 1
   FNG alarm time         : 2.5 seconds
   FNG reset time         : 10 seconds

   All RMEPs are dead     : False
```



```
RDI present           : False

Fault identified      : False

RMEP-Id               : 1
RMEG-Name             : INAIRTEL/meg-b
RMEP CCM defect       : False
RMEP last RDI         : False
```

1:1 Co-Routed Bidirectional Linear Protection Switching

Pseudowire and IPv4 map route traffic are supported in 1:1 Bidirectional Protection Scheme.

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp protection-group grp1`	Configure protection group as grp1.
`(config-pg)#primary meg meg1 mep-id 1`	Configure primary meg as meg1.
`(config-pg)#backup meg meg3 mep-id 1`	Configure backup meg as meg3.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp protection-group grp1`	Configure protection group as grp1.
`(config-pg)#primary meg meg2 mep-id 2`	Configure primary MEG as meg1.
`(config-pg)#backup meg meg4 mep-id 4`	Configure backup MEG as meg2.

Validation

```
PE1#sh mpls-tp protection-group summary

Total Number of PS groups configured : 1
-----------------------------------------------------------------------------------------
Group-Name       Primary-Meg      Pri-Me Name/ID   Backup-Meg       Bkp-Me Name/ID  Oper-
Status
-----------------------------------------------------------------------------------------
grp1             meg1             1                 meg3             1                 UP

PE1#sh mpls-tp protection-group
<===============================================================================>
 Group Name         : grp1          Oper Status       : Up
 Revertive mode     : Revertive     Protection-scheme : Bidirectional(1:1)
 WTR timer          : 300 sec       Hold-off timer    : 0 sec
 Rapid tx freq      : 3300 usec     Continual tx freq : 5 sec
 Primary meg        : meg1          Backup meg        : meg3
```

```
 Primary mep-id    : 1               Backup mep-id     : 1
 Group-Type        : ITUT
--------------------------------------------------------------------------------
Current State     : No Request - Working
 Current Event     : Remote NR on working
 Active Path       : WORKING
--------------------------------------------------------------------------------
COUNTERS:
 Pkt-Tx            : 108             Pkt-Rx            : 106
 Invalid pkt       : 0               Scheme mismatch   : 0
 Mode mismatch     : 0               Start time        : 00:09:47

PE2#sh mpls-tp protection-group summary

Total Number of PS groups configured : 1
---------------------------------------------------------------------------------------
Group-Name       Primary-Meg      Pri-Me Name/ID   Backup-Meg      Bkp-Me Name/ID  Oper-
Status
---------------------------------------------------------------------------------------
grp1             meg2             2                meg4            4               UP

PE2#sh mpls-tp protection-group
<===============================================================================>
 Group Name        : grp1            Oper Status       : Up
 Revertive mode    : Revertive       Protection-scheme : Bidirectional(1:1)
 WTR timer         : 300 sec         Hold-off timer    : 0 sec
 Rapid tx freq     : 3300 usec       Continual tx freq : 5 sec
 Primary meg       : meg2            Backup meg        : meg4
 Primary mep-id    : 2               Backup mep-id     : 4
 Group-Type        : ITUT
--------------------------------------------------------------------------------
 Current State     : No Request - Working
 Current Event     : Remote NR on working
 Active Path       : WORKING
--------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx            : 11628           Pkt-Rx            : 131
 Invalid pkt       : 0               Scheme mismatch   : 0
 Mode mismatch     : 0               Start time        : 16:09:06

PE1#sh mpls-tp tunnel
<===============================================================================>
 Tunnel-id             : 1              Tunnel-Name         : primary-tunnel
 Source ICC-Oper-ID    : INAIRTEL       Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL       Destination Node-Id : 4.4.4.4
 Role  : Source                         Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)        Tunnel State        : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001             Outgoing-Interface : eth1
```

```
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2003              Incoming-Interface  : eth1
       ILM-Index      : 1                 Cross-Connect-Index : 2
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 1              ME Index        : 1
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Primary
        PS State       : Normal
        Peer Tunnel-name: backup-tunnel
<================================================================================>
<================================================================================>
 Tunnel-id             : 2                Tunnel-Name         : backup-tunnel
 Source ICC-Oper-ID    : INAIRTEL         Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL         Destination Node-Id : 4.4.4.4
 Role  : Source                           Tunnel Index        : 2
 Mode  : COROUTED(bidirectional)          Tunnel State        : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 101               Outgoing-Interface : eth2
       NHLFE Index    : 3
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 203               Incoming-Interface  : eth2
       ILM-Index      : 2                 Cross-Connect-Index : 4
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 2              ME Index        : 1
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Backup
        PS State       : Normal
        Peer Tunnel-name: primary-tunnel

PE2#sh mpls-tp tunnel
<================================================================================>
```

```
 Tunnel-id              : 1                 Tunnel-Name         : primary-tunnel
 Source ICC-Oper-ID     : INAIRTEL          Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL           Destination Node-Id : 4.4.4.4
 Role  : Destination                        Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)            Tunnel State        : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1003               Incoming-Interface  : eth1
       ILM-Index      : 1                  Cross-Connect-Index : 1
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2001               Outgoing-Interface : eth1
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 1             ME Index        : 2
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Primary
        PS State       : Normal
        Peer Tunnel-name: backup-tunnel
<================================================================================>
<================================================================================>
 Tunnel-id              : 2                 Tunnel-Name         : backup-tunnel
 Source ICC-Oper-ID     : INAIRTEL          Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL           Destination Node-Id : 4.4.4.4
 Role  : Destination                        Tunnel Index        : 2
 Mode  : COROUTED(bidirectional)            Tunnel State        : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 103                Incoming-Interface  : eth2
       ILM-Index      : 2                  Cross-Connect-Index : 3
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 201                Outgoing-Interface : eth2
       NHLFE Index    : 4
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 2             ME Index        : 4
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
```

```
--------------------------------------------------------
  Protection Group Name  : grp1
--------------------------------------------------------
   PS Role        : Backup
   PS State       : Normal
   Peer Tunnel-name: primary-tunnel
```

1:1 Associated Bidirectional Linear Protection Switching

Pseudowire and IPV4 map route traffic are supported in 1:1 bidirectional protection scheme.

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp protection-group grp1`	Configure protection group as grp1
`(config-pg)#primary meg meg-p mep-id 1`	Configure primary meg as meg-p.
`(config-pg)#backup meg meg-b mep-id 1`	Configure backup meg as meg-b.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp protection-group grp1`	Configure protection group as grp1
`(config-pg)#primary meg meg-p mep-id 4`	Configure primary meg as meg-p.
`(config-pg)#backup meg meg-b mep-id 4`	Configure backup meg as meg-b.

Validation

```
PE1#sh mpls-tp protection-group
<=================================================================================>
 Group Name          : grp1             Oper Status        : Up
 Revertive mode      : Revertive        Protection-scheme  : Bidirectional(1:1)
 WTR timer           : 300 sec          Hold-off timer     : 0 sec
 Rapid tx freq       : 3300 usec        Continual tx freq  : 5 sec
 Primary meg         : meg-p            Backup meg         : meg-b
 Primary mep-id      : 1                Backup mep-id      : 1
 Group-Type          : ITUT
-------------------------------------------------------------------------------
 Current State       : No Request - Working
 Current Event       : Remote NR on working
 Active Path         : WORKING
-------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx              : 108              Pkt-Rx             : 106
 Invalid pkt         : 0                Scheme mismatch    : 0
 Mode mismatch       : 0                Start time         : 00:09:47
```

```
********************************************************************************
PE1#sh mpls-tp protection-group summary

Total Number of PS groups configured : 1
-----------------------------------------------------------------------------------------
Group-Name       Primary-Meg      Pri-Me Name/ID   Backup-Meg      Bkp-Me Name/ID  Oper-
Status
-----------------------------------------------------------------------------------------
grp1             meg-p            1                meg-b           1               UP

PE1#sh mpls-tp protection-group grp1
<================================================================================>
 Group Name         : grp1            Oper Status        : Up
 Revertive mode     : Revertive       Protection-scheme : Bidirectional(1:1)
 WTR timer          : 300 sec         Hold-off timer     : 0 sec
 Rapid tx freq      : 3300 usec       Continual tx freq : 5 sec
 Primary meg        : meg-p           Backup meg         : meg-b
 Primary mep-id     : 1               Backup mep-id      : 1
 Group-Type         : ITUT
---------------------------------------------------------------------------------
 Current State      : No Request - Working
 Current Event      : Remote NR on working
 Active Path        : WORKING
---------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx             : 116             Pkt-Rx             : 114
 Invalid pkt        : 0               Scheme mismatch    : 0
 Mode mismatch      : 0               Start time         : 00:10:24
********************************************************************************

PE1#sh mpls-tp tunnel
<================================================================================>
 Tunnel-id              : 1              Tunnel-Name         : primary-forward
 Source ICC-Oper-ID     : INAIRTEL       Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Source                          Tunnel Index        : 1
 Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
 Associated-Tunnel   : primary-reverse

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001             Outgoing-Interface : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     ----------------------------------------------------------
      MEG Index       : 1             ME Index        : 1
     ----------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ----------------------------------------------------------
       Protection Group Name  : grp1
```

```
    ---------------------------------------------------------
       PS Role        : Primary
       PS State       : Normal
       Peer Tunnel-name: backup-forward
<================================================================================>
<================================================================================>
 Tunnel-id              : 3              Tunnel-Name         : backup-forward
 Source ICC-Oper-ID     : INAIRTEL       Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Source                          Tunnel Index        : 2
 Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
 Associated-Tunnel    : backup-reverse

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2001              Outgoing-Interface : eth2
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 2             ME Index        : 1
     ---------------------------------------------------------
       Lock           : Disabled
       Loopback       : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
       PS Role        : Backup
       PS State       : Normal
       Peer Tunnel-name: primary-forward
<================================================================================>
<================================================================================>
 Tunnel-id              : 2              Tunnel-Name         : primary-reverse
 Source ICC-Oper-ID     : INAIRTEL       Source Node-Id      : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 1.1.1.1
 Role  : Destination                     Tunnel Index        : 3
 Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
 Associated-Tunnel    : primary-forward

     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 3002              Incoming-Interface  : eth4
       ILM-Index      : 1                 Cross-Connect-Index : 3
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 3             ME Index        : 11
     ---------------------------------------------------------
       Lock           : Disabled
       Loopback       : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
```

```
        PS Role        : Primary
        PS State       : Normal
        Peer Tunnel-name: backup-reverse
<==============================================================================>
<==============================================================================>
 Tunnel-id             : 4               Tunnel-Name         : backup-reverse
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 1.1.1.1
 Role  : Destination                     Tunnel Index        : 4
 Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
 Associated-Tunnel   : backup-forward

     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 4002              Incoming-Interface  : eth3
       ILM-Index      : 2                 Cross-Connect-Index : 4
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 4             ME Index        : 11
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Backup
        PS State       : Normal
        Peer Tunnel-name: primary-reverse
<==============================================================================>

PE2#sh mpls-tp protection-group summary

Total Number of PS groups configured : 1
--------------------------------------------------------------------------------------
------------
Group-Name       Primary-Meg      Pri-Me Name/ID   Backup-Meg      Bkp-Me Name/ID  Oper-
Status
--------------------------------------------------------------------------------------
-------------
grp1             meg-p            4                meg-b           4                UP

PE2#sh mpls-tp protection-group
<==============================================================================>
 Group Name        : grp1           Oper Status       : Up
 Revertive mode    : Revertive      Protection-scheme : Bidirectional(1:1)
 WTR timer         : 300 sec        Hold-off timer    : 0 sec
 Rapid tx freq     : 3300 usec      Continual tx freq : 5 sec
 Primary meg       : meg-p          Backup meg        : meg-b
 Primary mep-id    : 4              Backup mep-id     : 4
 Group-Type        : ITUT
--------------------------------------------------------------------------------
 Current State     : No Request - Working
```

```
 Current Event      : Remote NR on working
 Active Path        : WORKING
--------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx             : 11626           Pkt-Rx             : 129
 Invalid pkt        : 0               Scheme mismatch    : 0
 Mode mismatch      : 0               Start time         : 16:09:02
*********************************************************************************
PE2#sh mpls-tp protection-group grp1
<===============================================================================>
 Group Name         : grp1            Oper Status        : Up
 Revertive mode     : Revertive       Protection-scheme : Bidirectional(1:1)
 WTR timer          : 300 sec         Hold-off timer     : 0 sec
 Rapid tx freq      : 3300 usec       Continual tx freq : 5 sec
 Primary meg        : meg-p           Backup meg         : meg-b
 Primary mep-id     : 4               Backup mep-id      : 4
 Group-Type         : ITUT
--------------------------------------------------------------------------------
 Current State      : No Request - Working
 Current Event      : Remote NR on working
 Active Path        : WORKING
--------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx             : 11628           Pkt-Rx             : 131
 Invalid pkt        : 0               Scheme mismatch    : 0
 Mode mismatch      : 0               Start time         : 16:09:06
*********************************************************************************
PE2#sh mpls-tp tunnel
<===============================================================================>
 Tunnel-id              : 2               Tunnel-Name         : primary-reverse
 Source ICC-Oper-ID     : INAIRTEL        Source Node-Id      : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL         Destination Node-Id : 1.1.1.1
 Role   : Source                          Tunnel Index        : 1
 Mode   : ASSOCIATED(unidirectional)      Tunnel State        : UP
 Associated-Tunnel    : primary-forward

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 3001              Outgoing-Interface : eth3
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 1             ME Index        : 4
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Primary
```

```
        PS State       : Normal
        Peer Tunnel-name: backup-reverse
<================================================================================>
<================================================================================>
 Tunnel-id             : 4               Tunnel-Name         : backup-reverse
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 1.1.1.1
 Role  : Source                          Tunnel Index        : 2
 Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
 Associated-Tunnel   : backup-forward

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 4001              Outgoing-Interface : eth4
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 2             ME Index        : 4
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Backup
        PS State       : Normal
        Peer Tunnel-name: primary-reverse
<================================================================================>
<================================================================================>
 Tunnel-id             : 1               Tunnel-Name         : primary-forward
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Destination                     Tunnel Index        : 3
 Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
 Associated-Tunnel   : primary-reverse

     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1003              Incoming-Interface  : eth1
       ILM-Index      : 1                 Cross-Connect-Index : 3
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 3             ME Index        : 44
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Primary
        PS State       : Normal
```

```
        Peer Tunnel-name: backup-forward
<================================================================================>
<================================================================================>
 Tunnel-id             : 3               Tunnel-Name         : backup-forward
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Destination                     Tunnel Index        : 4
 Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
 Associated-Tunnel   : backup-reverse

     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2003              Incoming-Interface  : eth2
       ILM-Index      : 2                 Cross-Connect-Index : 4
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 4              ME Index        : 44
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Backup
        PS State       : Normal
        Peer Tunnel-name: primary-forward
```

1+1 Associated Unidirectional Linear Protection Switching

PE1 (OAM)

#configure terminal	Enter configure mode.
(config)#mpls-tp protection-group grp1	Configure protection group as grp1.
(config-pg)#protection-scheme unidirectional permanent	Set the protection scheme.
(config-pg)#primary meg meg-p mep-id 1	Configure primary meg as meg-p.
(config-pg)#backup meg meg-b mep-id 1	Configure backup meg as meg-b.

PE2 (OAM)

#configure terminal	Enter configure mode.
(config)#mpls-tp protection-group grp1	Configure protection group as grp1.
(config-pg)#protection-scheme unidirectional permanent	Set the protection scheme.

`(config-pg)#primary meg meg-p mep-id 4`	Configure primary meg as meg-p.
`(config-pg)#backup meg meg-b mep-id 4`	Configure backup meg as meg-b.

Validation

```
PE1#sh mpls-tp protection-group summary

Total Number of PS groups configured : 1
------------------------------------------------------------------------------------------
Group-Name       Primary-Meg      Pri-Me Name/ID   Backup-Meg       Bkp-Me Name/ID  Oper-
Status
------------------------------------------------------------------------------------------
grp1             meg-p             1                meg-b            1               UP

PE1#sh mpls-tp protection-group
<===================================================================================>
 Group Name         : grp1            Oper Status       : Up
 Revertive mode     : Revertive       Protection-scheme : Unidirectional(1+1)
 WTR timer          : 300 sec         Hold-off timer    : 0 sec
 Rapid tx freq      : 3300 usec       Continual tx freq : 5 sec
 Primary meg        : meg-p           Backup meg        : meg-b
 Primary mep-id     : 1               Backup mep-id     : 1
 Group-Type         : ITUT
-----------------------------------------------------------------------------------
 Current State      : No Request - Working
 Current Event      : Remote NR on working
 Active Path        : WORKING
-----------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx             : 177             Pkt-Rx            : 170
 Invalid pkt        : 0               Scheme mismatch   : 0
 Mode mismatch      : 0               Start time        : 00:19:09
*************************************************************************************
PE1#sh mpls-tp protection-group grp1
<===================================================================================>
 Group Name         : grp1            Oper Status       : Up
 Revertive mode     : Revertive       Protection-scheme : Unidirectional(1+1)
 WTR timer          : 300 sec         Hold-off timer    : 0 sec
 Rapid tx freq      : 3300 usec       Continual tx freq : 5 sec
 Primary meg        : meg-p           Backup meg        : meg-b
 Primary mep-id     : 1               Backup mep-id     : 1
 Group-Type         : ITUT
-----------------------------------------------------------------------------------
 Current State      : No Request - Working
 Current Event      : Remote NR on working
 Active Path        : WORKING
-----------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx             : 177             Pkt-Rx            : 170
 Invalid pkt        : 0               Scheme mismatch   : 0
```



```
 Mode mismatch     : 0               Start time        : 00:19:13
********************************************************************************
PE1#show mpls-tp tunnel
<===============================================================================>
 Tunnel-id             : 1               Tunnel-Name         : primary-forward
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Source                          Tunnel Index        : 1
 Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
 Associated-Tunnel   : primary-reverse

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001              Outgoing-Interface : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 1              ME Index        : 1
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Primary
        PS State       : Normal
        Peer Tunnel-name: backup-forward
<================================================================================>
<===============================================================================>
 Tunnel-id             : 3               Tunnel-Name         : backup-forward
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
 Role  : Source                          Tunnel Index        : 2
 Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
 Associated-Tunnel   : backup-reverse

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2001              Outgoing-Interface : eth2
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 2              ME Index        : 1
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Backup
```

```
        PS State       : Normal
        Peer Tunnel-name: primary-forward
<================================================================================>
<================================================================================>
 Tunnel-id             : 2               Tunnel-Name         : primary-reverse
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 1.1.1.1
 Role  : Destination                     Tunnel Index        : 3
 Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
 Associated-Tunnel   : primary-forward

     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 3002              Incoming-Interface  : eth4
       ILM-Index      : 1                 Cross-Connect-Index : 3
       Status : UP
     ----------------------------------------------------------
      MEG Index       : 3             ME Index        : 11
     ----------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ----------------------------------------------------------
       Protection Group Name  : grp1
     ----------------------------------------------------------
        PS Role        : Primary
        PS State       : Normal
        Peer Tunnel-name: backup-reverse
<================================================================================>
<================================================================================>
 Tunnel-id             : 4               Tunnel-Name         : backup-reverse
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 1.1.1.1
 Role  : Destination                     Tunnel Index        : 4
 Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
 Associated-Tunnel   : backup-forward

     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 4002              Incoming-Interface  : eth3
       ILM-Index      : 2                 Cross-Connect-Index : 4
       Status : UP
     ----------------------------------------------------------
      MEG Index       : 4             ME Index        : 11
     ----------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ----------------------------------------------------------
       Protection Group Name  : grp1
     ----------------------------------------------------------
        PS Role        : Backup
        PS State       : Normal
        Peer Tunnel-name: primary-reverse
```



```
<================================================================================>

PE2#show mpls-tp protection-group summary

Total Number of PS groups configured : 1
------------------------------------------------------------------------------------------
Group-Name       Primary-Meg      Pri-Me Name/ID   Backup-Meg       Bkp-Me Name/ID  Oper-
Status
------------------------------------------------------------------------------------------
grp1             meg-p            4                meg-b            4               UP

PE2#show mpls-tp protection-group
<================================================================================>
 Group Name         : grp1            Oper Status       : Up
 Revertive mode     : Revertive       Protection-scheme : Unidirectional(1+1)
 WTR timer          : 300 sec         Hold-off timer    : 0 sec
 Rapid tx freq      : 3300 usec       Continual tx freq : 5 sec
 Primary meg        : meg-p           Backup meg        : meg-b
 Primary mep-id     : 4               Backup mep-id     : 4
 Group-Type         : ITUT
--------------------------------------------------------------------------------
 Current State      : No Request - Working
 Current Event      : Remote NR on working
 Active Path        : WORKING
--------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx             : 11669           Pkt-Rx            : 172
 Invalid pkt        : 0               Scheme mismatch   : 0
 Mode mismatch      : 0               Start time        : 16:17:40
*********************************************************************************
PE2#show mpls-tp protection-group grp1
<================================================================================>
 Group Name         : grp1            Oper Status       : Up
 Revertive mode     : Revertive       Protection-scheme : Unidirectional(1+1)
 WTR timer          : 300 sec         Hold-off timer    : 0 sec
 Rapid tx freq      : 3300 usec       Continual tx freq : 5 sec
 Primary meg        : meg-p           Backup meg        : meg-b
 Primary mep-id     : 4               Backup mep-id     : 4
 Group-Type         : ITUT
--------------------------------------------------------------------------------
 Current State      : No Request - Working
 Current Event      : Remote NR on working
 Active Path        : WORKING
--------------------------------------------------------------------------------
 COUNTERS:
 Pkt-Tx             : 11669           Pkt-Rx            : 172
 Invalid pkt        : 0               Scheme mismatch   : 0
 Mode mismatch      : 0               Start time        : 16:17:45
*********************************************************************************
PE2#show mpls-tp tunnel
<================================================================================>
```

```
 Tunnel-id             : 2                Tunnel-Name         : primary-reverse
 Source ICC-Oper-ID    : INAIRTEL         Source Node-Id      : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL         Destination Node-Id : 1.1.1.1
 Role  : Source                           Tunnel Index        : 1
 Mode  : ASSOCIATED(unidirectional)       Tunnel State        : UP
 Associated-Tunnel    : primary-forward

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 3001              Outgoing-Interface : eth3
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 1             ME Index        : 4
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Primary
        PS State       : Normal
        Peer Tunnel-name: backup-reverse
<================================================================================>
<================================================================================>
 Tunnel-id             : 4                Tunnel-Name         : backup-reverse
 Source ICC-Oper-ID    : INAIRTEL         Source Node-Id      : 4.4.4.4
 Destination ICC-Oper-ID: INAIRTEL         Destination Node-Id : 1.1.1.1
 Role  : Source                           Tunnel Index        : 2
 Mode  : ASSOCIATED(unidirectional)       Tunnel State        : UP
 Associated-Tunnel    : backup-forward

     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 4001              Outgoing-Interface : eth4
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 2             ME Index        : 4
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role        : Backup
        PS State       : Normal
        Peer Tunnel-name: primary-reverse
<================================================================================>
<================================================================================>
```

```
Tunnel-id             : 1               Tunnel-Name         : primary-forward
Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
Role  : Destination                     Tunnel Index        : 3
Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
Associated-Tunnel   : primary-reverse

    Reverse-Path : ILM   <OPCODE : Pop>
      Incoming-Label : 1003              Incoming-Interface  : eth1
      ILM-Index      : 1                 Cross-Connect-Index : 3
      Status : UP
    ---------------------------------------------------------
     MEG Index       : 3             ME Index        : 44
    ---------------------------------------------------------
       Lock          : Disabled
       Loopback      : Disabled
    ---------------------------------------------------------
      Protection Group Name  : grp1
    ---------------------------------------------------------
       PS Role        : Primary
       PS State       : Normal
       Peer Tunnel-name: backup-forward
<===============================================================================>
<===============================================================================>
Tunnel-id             : 3               Tunnel-Name         : backup-forward
Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 4.4.4.4
Role  : Destination                     Tunnel Index        : 4
Mode  : ASSOCIATED(unidirectional)      Tunnel State        : UP
Associated-Tunnel   : backup-reverse

    Reverse-Path : ILM   <OPCODE : Pop>
      Incoming-Label : 2003              Incoming-Interface  : eth2
      ILM-Index      : 2                 Cross-Connect-Index : 4
      Status : UP
    ---------------------------------------------------------
     MEG Index       : 4             ME Index        : 44
    ---------------------------------------------------------
       Lock          : Disabled
       Loopback      : Disabled
    ---------------------------------------------------------
      Protection Group Name  : grp1
    ---------------------------------------------------------
       PS Role        : Backup
       PS State       : Normal
       Peer Tunnel-name: primary-forward
```

CHAPTER 32 MPLS-TP Ring Protection Switching

This chapter contains configuration examples for the MPLS-TP Ring Protection Switching (RPS) feature.

Overview

The ZebOS-XP implementation of MPLS-TP RPS supports the wrapping scheme which defines ring protection switching for link and node failures over point-to-point (p-t-p) and point-to-multipoint (p-t-mp) Label Switched Paths (LSP).

MPLS also supports the following characteristics.

- Switching types
- Operation types

Topology

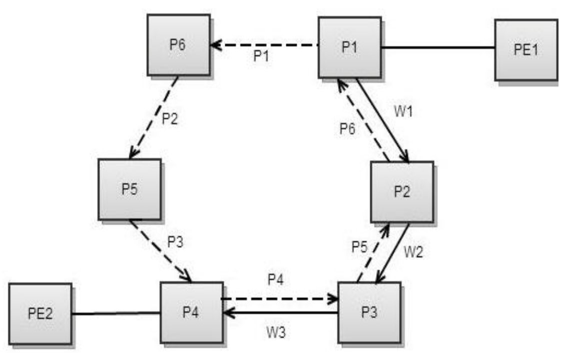


Figure 32-1: MPLS TP Ring Protection Switching Topology

Primary Tunnel Connection:

```
PE1(e1)---(e1)P1(e2)---(e1)P2(e4)---(e1)P3(e4)---(e2)P4(e3)---(e1)PE2
```

Backup tunnel connections :

```
P1(e3)---(e2)P2(e3)---(e2)P3(e3)---(e1)P4(e4)---(e1)P5(e2)---
--(e1)P6(e2)---(e4)P1
```

Configuring RPS Using ITU-T identifier

Primary Tunnel

PE1 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp itut cc IN icc AIRTEL node-id 1.1.1.1	Configure global configuration for ITUT tunnel.Configure country code as IN and ITU carrier code as AIRTEL with node-id as 1.1.1.1
(config)#interface eth1	Enter interface mode for eth1.
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure eth1 as provider interface and interface local id as 10.1.1.1
(config)#interface eth2	Enter interface mode for eth2.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure eth2 as provider interface and interface local id as 20.1.1.1
(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 6.6.6.6	Configure Tunnel with Tunnel id 1 originating from node PE1 (IN, AIRTEL, 1.1.1.1)to destination at PE2 node (IN, AIRTEL, 6.6.6.6)
(config-tnl)#tunnel-name primary	Configure tunnel with name primary
(config-tnl)#tunnel-mode bidirectional	Configure Co-routed mode of tunnel
(config-bidir-tnl)#forward-path nhlfe-entry 1001 eth1	Configure NHLFE entry to push the label at ingress for the forward path
(config-bidir-tnl)#reverse-path ilm-entry 2005 eth1 pop	Configure ILM-entry to pop the label at ingress for the reverse path

PE2 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp itut cc IN icc AIRTEL node-id 6.6.6.6	Configure global configuration for ITUT tunnel.Configure country code as IN and ITU carrier code as AIRTEL with node-id as 4.4.4.4
(config)#interface eth1	Enter interface mode for eth1.
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure eth1 as provider interface and interface local id as 10.1.1.1
(config)#interface eth2	Enter interface mode for eth2.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure eth2 as provider interface and interface local id as 20.1.1.1
(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 6.6.6.6	Configure Tunnel with Tunnel id 1 originating from node PE1 (IN, AIRTEL, 1.1.1.1) to destination at PE2 node (IN, AIRTEL, 4.4.4.4)
(config-tnl)#tunnel-name primary	Configure tunnel with name primary
(config-tnl)#tunnel-mode bidirectional	Configure Co-routed mode of tunnel

(config-bidir-tnl)#forward-path ilm-entry 1005 eth1 pop	Configure ILM entry to pop the label for forward path at egress
(config-bidir-tnl)#reverse-path nhlfe-entry 2001 eth1	Configure NHLF entry to push the label for reverse path at egress

P1 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp itut cc IN icc AIRTEL node-id 2.2.2.2	Configure global configuration for ITUT tunnel.Configure country code as IN and ITU carrier code as AIRTEL with node-id as 2.2.2.2
(config)#interface eth1	Enter interface mode for eth1.
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure eth1 as provider interface and interface local id as 10.1.1.1
(config)#interface eth2	Enter interface mode for eth2.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure eth2 as provider interface and interface local id as 20.1.1.1
(config)#interface eth3	Enter interface mode for eth3.
(config-if)#mpls-tp provider-interface 30.1.1.1	Configure eth1 as provider interface and interface local id as 10.1.1.1
(config)#interface eth4	Enter interface mode for eth4.
(config-if)#mpls-tp provider-interface 40.1.1.1	Configure eth4 as provider interface and interface local id as 40.1.1.1
(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 6.6.6.6	Configure Tunnel with Tunnel id 1 originating from node PE1 (IN, AIRTEL, 1.1.1.1) to destination at PE2 node (IN, AIRTEL, 6.6.6.6)
(config-tnl)#tunnel-name primary-tunnel	Configure tunnel with name primary-tunnel
(config-tnl)#tunnel-mode bidirectional	Configure Co-routed mode of tunnel
(config-bidir-tnl)#forward-path ilm-entry 3006 eth3 swap 3001 eth4	Configure ILM entry to swap the labels at transit for the forward path
(config-bidir-tnl)#reverse-path ilm-entry 4006 eth4 swap 4001 eth3	Configure ILM entry to swap the labels at transit for the reverse path

P2 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp itut cc IN icc AIRTEL node-id 3.3.3.3	Configure global configuration for ITUT tunnel.Configure country code as IN and ITU carrier code as AIRTEL with node-id as 3.3.3.3
(config)#interface eth1	Enter interface mode for eth1.
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure eth1 as provider interface and interface local id as 10.1.1.1
(config)#interface eth2	Enter interface mode for eth2.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure eth2 as provider interface and interface local id as 20.1.1.1
(config)#interface eth3	Enter interface mode for eth3.
(config-if)#mpls-tp provider-interface 30.1.1.1	Configure eth1 as provider interface and interface local id as 10.1.1.1

(config)#interface eth4	Enter interface mode for eth4.
(config-if)#mpls-tp provider-interface 40.1.1.1	Configure eth4 as provider interface and interface local id as 40.1.1.1
(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN	Configure Tunnel with Tunnel id 1 originating from node PE1 (IN, AIRTEL, 1.1.1.1) to destination at PE2 node (IN, AIRTEL, 6.6.6.6)
(config-tnl)#tunnel-name primary-tunnel	Configure tunnel with name primary-tunnel
(config-tnl)#tunnel-mode bidirectional	Configure Co-routed mode of tunnel
(config-bidir-tnl)#forward-path ilm-entry 1002 eth1 swap 1003 eth4	Configure ILM entry to swap the labels at transit for the forward path
(config-bidir-tnl)#reverse-path ilm-entry 2003 eth4 swap 2004 eth1	Configure ILM entry to swap the labels at transit for the reverse path

P3 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp itut cc IN icc AIRTEL node-id 4.4.4.4	Configure global configuration for ITUT tunnel.Configure country code as IN and ITU carrier code as AIRTEL with node-id as 4.4.4.4
(config)#interface eth1	Enter interface mode for eth1.
(config-if)#mpls-tp provider-interface 10.1.1.1	Configure eth1 as provider interface and interface local id as 10.1.1.1
(config)#interface eth2	Enter interface mode for eth2.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure eth2 as provider interface and interface local id as 20.1.1.1
(config)#interface eth3	Enter interface mode for eth3.
(config-if)#mpls-tp provider-interface 30.1.1.1	Configure eth1 as provider interface and interface local id as 10.1.1.1
(config)#interface eth4	Enter interface mode for eth4.
(config-if)#mpls-tp provider-interface 40.1.1.1	Configure eth4 as provider interface and interface local id as 40.1.1.1
(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 6.6.6.6	Configure Tunnel with Tunnel id 1 originating from node PE1 (IN, AIRTEL, 1.1.1.1) to destination at PE2 node (IN, AIRTEL, 6.6.6.6)
(config-tnl)#tunnel-name primary	Configure tunnel with name primary
(config-tnl)#tunnel-mode bidirectional	Configure Co-routed mode of tunnel
(config-bidir-tnl)#forward-path ilm-entry 1003 eth1 swap 1004 eth4	Configure ILM entry to swap the labels at transit for the forward path
(config-bidir-tnl)#reverse-path ilm-entry 2002 eth4 swap 2003 eth1	Configure ILM entry to swap the labels at transit for the reverse path

P4 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp itut cc IN icc AIRTEL node-id 5.5.5.5	Configure global configuration for ITUT tunnel.Configure country code as IN and ITU carrier code as AIRTEL with node-id as 5.5.5.5
(config)#interface eth1	Enter interface mode for eth1.

(config-if)#mpls-tp provider-interface 10.1.1.1	Configure eth1 as provider interface and interface local id as 10.1.1.1
(config)#interface eth2	Enter interface mode for eth2.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure eth2 as provider interface and interface local id as 20.1.1.1
(config)#interface eth3	Enter interface mode for eth3.
(config-if)#mpls-tp provider-interface 30.1.1.1	Configure eth1 as provider interface and interface local id as 10.1.1.1
(config)#interface eth4	Enter interface mode for eth4.
(config-if)#mpls-tp provider-interface 40.1.1.1	Configure eth4 as provider interface and interface local id as 40.1.1.1
(config)#mpls-tp tunnel 1 source IN AIRTEL 1.1.1.1 destination IN AIRTEL 6.6.6.6	Configure Tunnel with Tunnel id 1 originating from node PE1 (IN, AIRTEL, 1.1.1.1) to destination at PE2 node (IN, AIRTEL, 6.6.6.6)
(config-tnl)#tunnel-name primary-tunnel	Configure tunnel with name primary-tunnel
(config-tnl)#tunnel-mode bidirectional	Configure Co-routed mode of tunnel
(config-bidir-tnl)#forward-path ilm-entry 1004 eth2 swap 1005 eth3	Configure ILM entry to swap the labels at transit for the forward path
(config-bidir-tnl)#reverse-path ilm-entry 2001 eth3 swap 2002 eth2	Configure ILM entry to swap the labels at transit for the reverse path

Ring Tunnel

P1 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp ring-tunnel 2	Configure ring tunnel with id as 2
(config-tnl)#tunnel-name backup	Configure tunnel with name backup
(config-tnl)#tunnel-mode bidirectional	Configure Co-routed mode of tunnel
(config-bidir-tnl)#forward-path ilm-entry 3006 eth3 swap 3001 eth4	Configure ILM entry to swap the labels at transit for the forward path
(config-bidir-tnl)#reverse-path ilm-entry 4006 eth4 swap 4001 eth3	Configure ILM entry to swap the labels at transit for the reverse path

P2 (NSM)

#configure terminal	Enter configure mode.
(config)#mpls-tp ring-tunnel 2	Configure ring tunnel with id as 2
(config-tnl)#tunnel-name backup	Configure tunnel with name backup
(config-tnl)#tunnel-mode bidirectional	Configure Co-routed mode of tunnel
(config-bidir-tnl)#forward-path ilm-entry 3004 eth3 swap 3005 eth2	Configure ILM entry to swap the labels at transit for the forward path
(config-bidir-tnl)#reverse-path ilm-entry 4002 eth2 swap 4003 eth3	Configure ILM entry to swap the labels at transit for the reverse path

P3 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp ring-tunnel 2`	Configure ring tunnel with id as 2
`(config-tnl)#tunnel-name backup`	Configure tunnel with name backup
`(config-tnl)#tunnel-mode bidirectional`	Configure Co-routed mode of tunnel
`(config-bidir-tnl)#forward-path ilm-entry 3005 eth3 swap 3006 eth2`	Configure ILM entry to swap the labels at transit for the forward path
`(config-bidir-tnl)#reverse-path ilm-entry 4001 eth2 swap 4002 eth3`	Configure ILM entry to swap the labels at transit for the reverse path

P4 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp ring-tunnel 2`	Configure ring tunnel with id as 2
`(config-tnl)#tunnel-name backup`	Configure tunnel with name backup
`(config-tnl)#tunnel-mode bidirectional`	Configure Co-routed mode of tunnel
`(config-bidir-tnl)#forward-path ilm-entry 3003 eth4 swap 3004 eth1`	Configure ILM entry to swap the labels at transit for the forward path
`(config-bidir-tnl)#reverse-path ilm-entry 4003 eth1 swap 4004 eth4`	Configure ILM entry to swap the labels at transit for the reverse path

P5 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 7.7.7.7`	Configure global configuration for ITUT tunnel.Configure country code as IN and ITU carrier code as AIRTEL with node-id as 5.5.5.5
`(config)#mpls-tp ring-tunnel 2`	Configure ring tunnel with id as 2
`(config-tnl)#tunnel-name backup`	Configure tunnel with name backup
`(config-tnl)#tunnel-mode bidirectional`	Configure Co-routed mode of tunnel
`(config-bidir-tnl)#forward-path ilm-entry 3002 eth2 swap 3003 eth1`	Configure ILM entry to swap the labels at transit for the forward path
`(config-bidir-tnl)#reverse-path ilm-entry 4004 eth1 swap 4005 eth2`	Configure ILM entry to swap the labels at transit for the reverse path
`#configure terminal`	Enter configure mode.
`(config)#mpls-tp ring-tunnel 2`	Configure ring tunnel with id as 2
`(config-tnl)#tunnel-name backup`	Configure tunnel with name backup
`(config-tnl)#tunnel-mode bidirectional`	Configure Co-routed mode of tunnel
`(config-bidir-tnl)#forward-path ilm-entry 3003 eth4 swap 3004 eth1`	Configure ILM entry to swap the labels at transit for the forward path
`(config-bidir-tnl)#reverse-path ilm-entry 4003 eth1 swap 4004 eth4`	Configure ILM entry to swap the labels at transit for the reverse path

P6 (NSM)

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 8.8.8.8`	Configure global configuration for ITUT tunnel.Configure country code as IN and ITU carrier code as AIRTEL with node-id as 5.5.5.5
`(config)#mpls-tp ring-tunnel 2`	Configure ring tunnel with id as 2
`(config-tnl)#tunnel-name backup`	Configure tunnel with name backup-tunnel
`(config-tnl)#tunnel-mode bidirectional`	Configure Co-routed mode of tunnel
`(config-bidir-tnl)#forward-path ilm-entry 3001 eth2 swap 3002 eth1`	Configure ILM entry to swap the labels at transit for the forward path
`(config-bidir-tnl)#reverse-path ilm-entry 4005 eth1 swap 4006 eth2`	Configure ILM entry to swap the labels at transit for the reverse path
`#configure terminal`	Enter configure mode.
`(config)#mpls-tp itut cc IN icc AIRTEL node-id 8.8.8.8`	Configure global configuration for ITUT tunnel.Configure country code as IN and ITU carrier code as AIRTEL with node-id as 5.5.5.5
`(config)#mpls-tp ring-tunnel 2`	Configure ring tunnel with id as 2
`(config-tnl)#tunnel-name backup`	Configure tunnel with name backup-tunnel
`(config-tnl)#tunnel-mode bidirectional`	Configure Co-routed mode of tunnel
`(config-bidir-tnl)#forward-path ilm-entry 3001 eth2 swap 3002 eth1`	Configure ILM entry to swap the labels at transit for the forward path

MEG Configuration for Tunnel

Corouted MEG Configuration

Primary Meg

PE1(OAM)

`#configure terminal`	Enter configure mode
`(config)#itut meg meg-1`	Configure the MEG name as meg-1
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel
`(config-itut-meg)#mep-id 1`	Configure MEP identifier as 1
`(config-itut-mp)#service tunnel primary`	Configure the service tunnel primary-tunnel to be associated with the ME
`(config-itut-mp)#rmep-id 6 cc IN icc BSNL umc meg-1`	Configure the remote MEP configuration

PE2 (OAM)

`#configure terminal`	Enter configure mode
`(config)#itut meg meg-1`	Configure the MEG name as meg-1

`(config-itut-meg)#service type tunnel`	Configure service type as tunnel
`(config-itut-meg)#mep-id 6`	Configure MEP identifier as 6
`(config-itut-mp)#service tunnel primary`	Configure the service tunnel primary-tunnel to be associated with the ME
`(config-itut-mp)#rmep-id 1 cc IN icc AIRTEL umc meg-1`	Configure the remote MEP configuration

P1 (OAM)

`#configure terminal`	Enter configure mode
`(config)#itut meg meg-1`	Configure the MEG name as meg-1
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel
`(config-itut-meg)#mip-id 2`	Configure MIP identifier as 2
`(config-itut-mp)#service tunnel primary-tunnel`	Configure the service tunnel primary-tunnel to be associated with the ME
`(config-itut-mp)#rmep-id 6 cc IN icc AIRTEL umc meg-1 fwd`	Configure the remote MEP configuration
`(config-itut-mp)#rmep-id 1 cc IN icc AIRTEL umc meg-1 rev`	Configure the remote MEP configuration

P2 (OAM)

`#configure terminal`	Enter configure mode
`(config)#itut meg meg-1`	Configure the MEG name as meg-1
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel
`(config-itut-meg)#mep-id 6`	Configure MEP identifier as 6
`(config-itut-mp)#service tunnel primary`	Configure the service tunnel primary-tunnel to be associated with the ME
`(config-itut-mp)#rmep-id 1 cc IN icc AIRTEL umc meg-1`	Configure the remote MEP configuration

P3 (OAM)

`#configure terminal`	Enter configure mode
`(config)#itut meg meg-1`	Configure the MEG name as meg-1
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel
`(config-itut-meg)#mip-id 4`	Configure MIP identifier as 2
`(config-itut-mp)#service tunnel primary`	Configure the service tunnel primary-tunnel to be associated with the ME
`(config-itut-mp)#rmep-id 6 cc IN icc AIRTEL umc meg-1 fwd`	Configure the remote MEP configuration
`(config-itut-mp)#rmep-id 1 cc IN icc AIRTEL umc meg-1 rev`	Configure the remote MEP configuration

P4 (OAM)

`#configure terminal`	Enter configure mode
`(config)#itut meg meg-1`	Configure the MEG name as meg-1
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel
`(config-itut-meg)#mip-id 5`	Configure MIP identifier as 5
`(config-itut-mp)#service tunnel primary`	Configure the service tunnel primary-tunnel to be associated with the ME
`(config-itut-mp)#rmep-id 6 cc IN icc AIRTEL umc meg-1 fwd`	Configure the remote MEP configuration
`(config-itut-mp)#rmep-id 1 cc IN icc AIRTEL umc meg-1 rev`	Configure the remote MEP configuration

Ring Meg

P1 (OAM)

`#configure terminal`	Enter configure mode
`(config)#itut meg meg-2`	Configure the MEG name as meg-2
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel
`(config-itut-meg)#mip-id 22`	Configure MIP identifier as 22
`(config-itut-mp)#service tunnel backup`	Configure the service tunnel backup-tunnel to be associated with the ME

P2 (OAM)

`#configure terminal`	Enter configure mode
`(config)#itut meg meg-2`	Configure the MEG name as meg-2
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel
`(config-itut-meg)#mip-id 33`	Configure MIP identifier as 33
`(config-itut-mp)#service tunnel backup`	Configure the service tunnel backup-tunnel to be associated with the ME

P3 (OAM)

`#configure terminal`	Enter configure mode
`(config)#itut meg meg-2`	Configure the MEG name as meg-2
`(config-itut-meg)#service type tunnel`	Configure service type as tunnel
`(config-itut-meg)#mip-id 44`	Configure MIP identifier as 44
`(config-itut-mp)#service tunnel backup`	Configure the service tunnel backup-tunnel to be associated with the ME

P4 (OAM)

#configure terminal	Enter configure mode
(config)#itut meg meg-2	Configure the MEG name as meg-2
(config-itut-meg)#service type tunnel	Configure service type as tunnel
(config-itut-meg)#mip-id 55	Configure MIP identifier as 55
(config-itut-mp)#service tunnel backup	Configure the service tunnel backup-tunnel to be associated with the ME

P5 (OAM)

#configure terminal	Enter configure mode
(config)#itut meg meg-2	Configure the MEG name as meg-1
(config-itut-meg)#service type tunnel	Configure service type as tunnel
(config-itut-meg)#mip-id 6	Configure MIP identifier as 6
(config-itut-mp)#service tunnel backup	Configure the service tunnel backup-tunnel to be associated with the ME

P6 (OAM)

#configure terminal	Enter configure mode
(config)#itut meg meg-3	Configure the MEG name as meg-3
(config-itut-meg)#service type tunnel	Configure service type as tunnel
(config-itut-meg)#mip-id 7	Configure MIP identifier as 7
(config-itut-mp)#service tunnel backup	Configure the service tunnel backup-tunnel to be associated with the ME

Datalink Meg

P1 (OAM)

#configure terminal	Enter configure mode
(config)#itut meg meg-d	Configure the MEG name as meg-d
(config-itut-meg)#service type datalink	Configure service type as datalink
(config-itut-meg)#mep-id 222	Configure MEP identifier 222
(config-itut-mp)#service datalink eth2	Configure the service datalink on eth2
(config-itut-mp)#continuity-check interval 3	Configure the CCM with interval 3
(config-itut-mp)#rmep-id 333 cc IN icc AIRTEL umc meg-d	Configure the remote MEP configuration

P2 (OAM)

`#configure terminal`	Enter configure mode
`(config)#itut meg megd2`	Configure the MEG name as megd2
`(config-itut-meg)#service type datalink`	Configure service type as datalink
`(config-itut-meg)#mep-id 3333`	Configure MEP identifier 3333
`(config-itut-mp)#service datalink eth4`	Configure the service datalink on eth4
`(config-itut-mp)#continuity-check interval 3`	Configure the CCM with interval 3
`(config-itut-mp)#rmep-id 444 cc IN icc AIRTEL umc megd2`	Configure the remote MEP configuration

P3 (OAM)

`#configure terminal`	Enter configure mode
`(config)#itut meg megd3`	Configure the MEG name as megd3
`(config-itut-meg)#service type datalink`	Configure service type as datalink
`(config-itut-meg)#mep-id 4444`	Configure MEP identifier 4444
`(config-itut-mp)#service datalink eth4`	Configure the service datalink on eth4
`(config-itut-mp)#continuity-check interval 3`	Configure the CCM with interval 3
`(config-itut-mp)#rmep-id 5555 cc IN icc AIRTEL umc megd3`	Configure the remote MEP configuration

P4 (OAM)

`#configure terminal`	Enter configure mode
`(config)#itut meg megd3`	Configure the MEG name as megd3
`(config-itut-meg)#service type datalink`	Configure service type as datalink
`(config-itut-meg)#mep-id 5555`	Configure MEP identifier 5555
`(config-itut-mp)#service datalink eth2`	Configure the service datalink on eth2
`(config-itut-mp)#continuity-check interval 3`	Configure the CCM with interval 3
`(config-itut-mp)#rmep-id 4444 cc IN icc AIRTEL umc megd3`	Configure the remote MEP configuration

P2 (OAM)

`#configure terminal`	Enter configure mode
`(config)#itut meg megd2`	Configure the MEG name as megd2
`(config-itut-meg)#service type datalink`	Configure service type as datalink

(config-itut-meg)#mep-id 3333	Configure MEP identifier 3333
(config-itut-mp)#service datalink eth4	Configure the service datalink on eth4
(config-itut-mp)#continuity-check interval 3	Configure the CCM with interval 3
(config-itut-mp)#rmep-id 444 cc IN icc AIRTEL umc megd2	Configure the remote MEP configuration

P2 (OAM)

#configure terminal	Enter configure mode
(config)#itut meg megd2	Configure the MEG name as megd2
(config-itut-meg)#service type datalink	Configure service type as datalink
(config-itut-meg)#mep-id 3333	Configure MEP identifier 3333
(config-itut-mp)#service datalink eth4	Configure the service datalink on eth4
(config-itut-mp)#continuity-check interval 3	Configure the CCM with interval 3
(config-itut-mp)#rmep-id 444 cc IN icc AIRTEL umc megd2	Configure the remote MEP configuration

Ring Protection Configuration

Bidirectional Corouted Tunnel

P1 (OAM)

#configure terminal	Enter configure mode.
(config)#mpls-tp rps protection-group grp1	Configure protection group as grp1
(config-meg)#primary meg meg-1 mip-id 2	Configure primary meg as meg-1.
(config-meg)#backup meg meg-2 mip-id 22	Configure backup meg as meg-2.

P2 (OAM)

#configure terminal	Enter configure mode.
(config)#mpls-tp rps protection-group grp1	Configure protection group as grp1
(config-meg)#primary meg meg-1 mip-id 3	Configure primary meg as meg-1.
(config-meg)#backup meg meg-2 mip-id 33	Configure backup meg as meg-2.

P3 (OAM)

#configure terminal	Enter configure mode.
(config)#mpls-tp rps protection-group grp1	Configure protection group as grp1

(config-meg)#primary meg meg-1 mip-id 4	Configure primary meg as meg-1.
(config-meg)#backup meg meg-2 mip-id 44	Configure backup meg as meg-2.

P4 (OAM)

#configure terminal	Enter configure mode.
(config)#mpls-tp rps protection-group grp1	Configure protection group as grp1
(config-meg)#primary meg meg-1 mip-id 5	Configure primary meg as meg-1.
(config-meg)#backup meg meg-2 mip-id 55	Configure backup meg as meg-2.

Validation

PE1

```
PE1#ping mpls-tp meg-name meg-1 mep-id 1
Discovering MP's on MEG: meg-1, Timeout 5 seconds
! seq_num = 1, cc:IN,  icc:AIRTEL,  umc:/meg-1,  ID:6
! seq_num = 2, cc:IN,  icc:AIRTEL,  umc:/meg-1,  ID:6
! seq_num = 3, cc:IN,  icc:AIRTEL,  umc:/meg-1,  ID:6

PE2#ping mpls-tp meg-name meg-1 mep-id 6
Discovering MP's on MEG: meg-1, Timeout 5 seconds
! seq_num = 1, cc:IN,  icc:AIRTEL,  umc:/meg-1,  ID:1
! seq_num = 2, cc:IN,  icc:AIRTEL,  umc:/meg-1,  ID:1
Edge node Output :
PE1#sh mpls-tp tunnel
<================================================================================>
 Tunnel-id             : 1                 Tunnel-Name          : primary
 Source ICC-Oper-ID    : INAIRTEL          Source Node-Id       : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL          Destination Node-Id : 6.6.6.6
 Role   : Source                           Tunnel Index         : 1
 Mode   : COROUTED(bidirectional)          Tunnel State         : UP
     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1001                Outgoing-Interface : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2005                Incoming-Interface  : eth1
       ILM-Index      : 1                   Cross-Connect-Index : 2
       Status : UP
     ----------------------------------------------------------
      MEG Index       : 1               ME Index        : 1
     ----------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
<===============================================================================>
PE1#sh meg summary
```

```
---------------------MEG-TYPE : IETF---------------------------------------
MEG-Name              Service-Type    ME-Name              MP Type    Oper-
Status
-------------------MEG-TYPE : ITUT---------------------------------------
MEG-Name            Service-Type    MEG-Level          MP-ID     MP Type
Oper-Status
INAIRTEL/meg-1       Tunnel          7                  1          MEP
UP
---------------------------------------------------------------------------
PE1#sh itut meg brief
=========================================================================
Maintenance Entity Group  : INAIRTEL/meg-1      MEG Index    : 1
Service Type              : Tunnel              MEG Level    : 7
   ---------------------------------------------------------------------------
   MP-ID                  : 1                   MP Type      : MEP
   Tunnel Name            : primary             Oper Status  : UP
   RMEP                   : INAIRTEL/meg-1,6
----------------------------------------------------------------------------
```

PE2

```
PE2#sh mpls-tp tunnel
<==========================================================================>
 Tunnel-id             : 1                Tunnel-Name          : primary
 Source ICC-Oper-ID    : INAIRTEL         Source Node-Id       : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL         Destination Node-Id : 6.6.6.6
 Role  : Destination                      Tunnel Index         : 1
 Mode  : COROUTED(bidirectional)          Tunnel State         : UP
     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1005               Incoming-Interface  : eth1
       ILM-Index      : 1                  Cross-Connect-Index : 1
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2001               Outgoing-Interface : eth1
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 1             ME Index        : 6
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
<=========================================================================>
PE2#sh meg summary
----------------------------------MEG-TYPE : IETF--------------------------
MEG-Name              Service-Type    ME-Name              MP Type    Oper-
Status
---------------------------------MEG-TYPE : ITUT---------------------------
MEG-Name            Service-Type    MEG-Level          MP-ID     MP Type
Oper-Status
INAIRTEL/meg-1       Tunnel          7                  6          MEP
UP
-------------------------------------------------------------------------
PE2#sh itut meg brief
======================================================================
Maintenance Entity Group  : INAIRTEL/meg-1      MEG Index    : 1
Service Type              : Tunnel              MEG Level    : 7
```

```
---------------------------------------------------------------------------
   MP-ID                  : 6                    MP Type      : MEP
   Tunnel Name            : primary              Oper Status  : UP
   RMEP                   : INAIRTEL/meg-1,1
---------------------------------------------------------------------------
```

Transit Node

P1

```
P1#sh mpls-tp tunnel
<==========================================================================>
 Tunnel-id             : 1                 Tunnel-Name         : primary
 Source ICC-Oper-ID    : INAIRTEL          Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL          Destination Node-Id : 6.6.6.6
 Role  : Transit                           Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)           Tunnel State        : UP
     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1001                Incoming-Interface  : eth1
       ILM-Index      : 1                   Cross-Connect-Index : 1
       Outgoing-Label : 1002                Outgoing-Interface  : eth2
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 2004                Incoming-Interface  : eth2
       ILM-Index      : 2                   Cross-Connect-Index : 2
       Outgoing-Label : 2005                Outgoing-Interface  : eth1
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 2              ME Index        : 2
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ---------------------------------------------------------
       Protection Group Name  : grp1
     ---------------------------------------------------------
        PS Role         : Primary
        PS State        : No Switch
        Peer Tunnel-name: backup
<==============================================================================>
<==============================================================================>
 Tunnel-id             : 2                 Tunnel-Name         : backup
 MPLS-TP tunnel type   : Ring tunnel
 Role  : Transit                           Tunnel Index        : 2
 Mode  : COROUTED(bidirectional)           Tunnel State        : UP
     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 3006                Incoming-Interface  : eth3
       ILM-Index      : 3                   Cross-Connect-Index : 3
       Outgoing-Label : 3001                Outgoing-Interface  : eth4
       NHLFE Index    : 3
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Swap>
```

```
        Incoming-Label : 4006             Incoming-Interface  : eth4
        ILM-Index      : 4                Cross-Connect-Index : 4
        Outgoing-Label : 4001             Outgoing-Interface  : eth3
        NHLFE Index    : 4
        BW-class       : N/A
        Status : UP
      ---------------------------------------------------------
       MEG Index       : 1             ME Index        : 22
      ---------------------------------------------------------
         Lock          : Disabled
         Loopback      : Disabled
      ---------------------------------------------------------
        Protection Group Name  : grp1
      ---------------------------------------------------------
         PS Role        : Backup
         PS State       : No Switch
         Peer Tunnel-name: primary
<=============================================================================>
P1#sh meg summary
-----------------------MEG-TYPE : IETF----------------------------------------
MEG-Name             Service-Type    ME-Name              MP Type    Oper-
Status
--------------------MEG-TYPE : ITUT----------------------------------------
MEG-Name            Service-Type   MEG-Level          MP-ID     MP Type
Oper-Status
INAIRTEL/meg-2       Tunnel          7                22         MIP
UP
INAIRTEL/meg-1       Tunnel          7                2          MIP
UP
INAIRTEL/meg-d       Datalink        7                222        MEP
UP
P1#sh mpls ilm-table
Codes: > - selected ILM, p - stale ILM, K - CLI ILM, T - MPLS-TP
Code  In-Label  Out-Label  In-Intf  Out-Intf  Nexthop            FEC
ILM-ID      LSP-Type
 T>   2004      2005      eth2     eth1      ffff.ffff.ffff.0000   N/A
2            LSP_DEFAULT
 T>   1001      1002      eth1     eth2      ffff.ffff.ffff.0000   N/A
1            LSP_DEFAULT
 T>   3006      3001      eth3     eth4      ffff.ffff.ffff.0000   N/A
3            LSP_DEFAULT
 T>   4006      4001      eth4     eth3      ffff.ffff.ffff.0000   N/A
4            LSP_DEFAULT
P1#sh mpls-tp rps protection-group
<==========================================================================>
 Group Name         : grp1           Oper Status       : Up
 Revertive mode     : Revertive
 WTR timer          : 300 sec        Hold-off timer    : 0 sec
 Primary meg        : meg-1          Backup meg        : meg-2
 Primary mip-id     : 2              Backup mip-id     : 22
 Group-Type         : ITUT
----------------------------------------------------------------------------
 Current State      : Idle
 Current Event      : Clear Signal Fail on primary
<============================================================================>
```

P2

```
P2#sh mpls-tp tunnel
```



```
<==========================================================================
=>
 Tunnel-id            : 1                 Tunnel-Name        : primary
 Source ICC-Oper-ID   : INAIRTEL          Source Node-Id     : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL         Destination Node-Id : 6.6.6.6
 Role  : Transit                          Tunnel Index       : 1
 Mode  : COROUTED(bidirectional)          Tunnel State       : UP
     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1002               Incoming-Interface  : eth1
       ILM-Index      : 1                  Cross-Connect-Index : 1
       Outgoing-Label : 1003               Outgoing-Interface  : eth4
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 2003               Incoming-Interface  : eth4
       ILM-Index      : 2                  Cross-Connect-Index : 2
       Outgoing-Label : 2004               Outgoing-Interface  : eth1
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
     ----------------------------------------------------------
      MEG Index       : 2               ME Index        : 3
     ----------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
     ----------------------------------------------------------
       Protection Group Name  : grp1
     ----------------------------------------------------------
        PS Role        : Primary
        PS State       : No Switch
        Peer Tunnel-name: backup
<==========================================================================>
<==========================================================================>
 Tunnel-id            : 2                 Tunnel-Name        : backup
 MPLS-TP tunnel type  : Ring tunnel
 Role  : Transit                          Tunnel Index       : 2
 Mode  : COROUTED(bidirectional)          Tunnel State       : UP

     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 3005               Incoming-Interface  : eth3
       ILM-Index      : 3                  Cross-Connect-Index : 3
       Outgoing-Label : 3006               Outgoing-Interface  : eth2
       NHLFE Index    : 3
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 4001               Incoming-Interface  : eth2
       ILM-Index      : 4                  Cross-Connect-Index : 4
       Outgoing-Label : 4002               Outgoing-Interface  : eth3
       NHLFE Index    : 4
       BW-class       : N/A
       Status : UP
     ----------------------------------------------------------
      MEG Index       : 3               ME Index        : 33
     ----------------------------------------------------------
        Lock          : Disabled
```

```
         Loopback      : Disabled
      ---------------------------------------------------------
        Protection Group Name  : grp1
      ---------------------------------------------------------
         PS Role        : Backup
         PS State       : No Switch
         Peer Tunnel-name: primary
<=============================================================================>
P2#sh meg summary
----------------------MEG-TYPE : IETF-----------------------------------------
MEG-Name             Service-Type    ME-Name              MP Type    Oper-
Status
----------------------MEG-TYPE : ITUT-----------------------------------------
MEG-Name           Service-Type   MEG-Level          MP-ID     MP Type
Oper-Status
INAIRTEL/meg-2      Tunnel          7                 33         MIP
UP
INAIRTEL/meg-1      Tunnel          7                 3          MIP
UP
INAIRTEL/meg-d      Datalink        7                 333        MEP
UP
INAIRTEL/megd2      Datalink        7                 3333       MEP
UP
-------------------------------------------------------------------------
P2#sh itut meg brief
=========================================================================
Maintenance Entity Group  : INAIRTEL/meg-2      MEG Index    : 3
Service Type              : Tunnel              MEG Level    : 7
--------------------------------------------------------------------------
   MP-ID                  : 33                  MP Type      : MIP
   Tunnel Name            : backup              Oper Status  : UP
----------------------------------------------------------------------------
   MP-ID                  : 33                  MP Type      : MIP
   Tunnel Name            : backup              Oper Status  : UP
=========================================================================
Maintenance Entity Group  : INAIRTEL/meg-1      MEG Index    : 2
Service Type              : Tunnel              MEG Level    : 7
-----------------------------------------------------------------------------
   MP-ID                  : 3                   MP Type      : MIP
   Tunnel Name            : primary             Oper Status  : UP
   RMEP                   : INAIRTEL/meg-1,6     Direction    : FWD
----------------------------------------------------------------------------
   MP-ID                  : 3                   MP Type      : MIP
   Tunnel Name            : primary             Oper Status  : UP
   RMEP                   : INAIRTEL/meg-1,1     Direction    : REV
==============================================================================
Maintenance Entity Group  : INAIRTEL/meg-d      MEG Index    : 1
Service Type              : Datalink            MEG Level    : 7
-----------------------------------------------------------------------------
   MP-ID                  : 333
   Provider Interface Name: eth1                Oper Status  : UP
   RMEP                   : INAIRTEL/meg-d,222
-----------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 3)
==============================================================================
Maintenance Entity Group  : INAIRTEL/megd2      MEG Index    : 4
Service Type              : Datalink            MEG Level    : 7
------------------------------------------------------------------------------
```



```
   MP-ID                  : 3333
   Provider Interface Name: eth4              Oper Status  : UP
   RMEP                   : INAIRTEL/megd2,444
 ---------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 3)
P2#sh mpls ilm-table
Codes: > - selected ILM, p - stale ILM, K - CLI ILM, T - MPLS-TP

Code  In-Label  Out-Label  In-Intf  Out-Intf  Nexthop             FEC
ILM-ID       LSP-Type
 T>   3005      3006      eth3     eth2      ffff.ffff.ffff.0000   N/A
3            LSP_DEFAULT
 T>   1002      1003      eth1     eth4      ffff.ffff.ffff.0000   N/A
1            LSP_DEFAULT
 T>   4001      4002      eth2     eth3      ffff.ffff.ffff.0000   N/A
4            LSP_DEFAULT
 T>   2003      2004      eth4     eth1      ffff.ffff.ffff.0000   N/A
2            LSP_DEFAULT
P2#sh mpls-tp cc summary
Total number of CC sessions configured : 2
------------------------------------------------------------------------------
MEG-Name             MP-Id           CCM-Interval         Oper status
----------------------------------------------------------------------------
INAIRTEL/meg-d       333             3                    Up
INAIRTEL/megd2       3333            3                    Up

P2#sh mpls-tp rps  protection-group
<=============================================================================>
 Group Name        : grp1            Oper Status       : Up
 Revertive mode    : Revertive
 WTR timer         : 300 sec         Hold-off timer    : 0 sec
 Primary meg       : meg-1           Backup meg        : meg-2
 Primary mip-id    : 3               Backup mip-id     : 33
 Group-Type        : ITUT
-----------------------------------------------------------------------------
 Current State     : Idle
 Current Event     : Clear Signal Fail on primary
<==============================================================================>
```

P3

```
P3#sh mpls-tp tunnel
<=============================================================================>
 Tunnel-id             : 1               Tunnel-Name         : primary
 Source ICC-Oper-ID    : INAIRTEL        Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL        Destination Node-Id : 6.6.6.6
 Role  : Transit                         Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)         Tunnel State        : UP
     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1003              Incoming-Interface  : eth1
       ILM-Index      : 1                 Cross-Connect-Index : 1
       Outgoing-Label : 1004              Outgoing-Interface  : eth4
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 2002              Incoming-Interface  : eth4
       ILM-Index      : 2                 Cross-Connect-Index : 2
```

```
        Outgoing-Label : 2003              Outgoing-Interface  : eth1
        NHLFE Index    : 2
        BW-class       : N/A
        Status : UP
      ---------------------------------------------------------
       MEG Index       : 2              ME Index        : 4
      ---------------------------------------------------------
         Lock          : Disabled
         Loopback      : Disabled
      ---------------------------------------------------------
        Protection Group Name  : grp1
      ---------------------------------------------------------
         PS Role        : Primary
         PS State       : No Switch
         Peer Tunnel-name: backup
 <======================================================================>
 <==========================================================================>
  Tunnel-id             : 2                Tunnel-Name         : backup
  MPLS-TP tunnel type   : Ring tunnel
  Role  : Transit                          Tunnel Index        : 2
  Mode  : COROUTED(bidirectional)          Tunnel State        : UP
      Forward-Path : ILM   <OPCODE : Swap>
        Incoming-Label : 3004              Incoming-Interface  : eth3
        ILM-Index      : 3                 Cross-Connect-Index : 3
        Outgoing-Label : 3005              Outgoing-Interface  : eth2
        NHLFE Index    : 3
        BW-class       : N/A
        Status : UP
      Reverse-Path : ILM   <OPCODE : Swap>
        Incoming-Label : 4002              Incoming-Interface  : eth2
        ILM-Index      : 4                 Cross-Connect-Index : 4
        Outgoing-Label : 4003              Outgoing-Interface  : eth3
        NHLFE Index    : 4
        BW-class       : N/A
        Status : UP
      ---------------------------------------------------------
       MEG Index       : 3              ME Index        : 44
      ---------------------------------------------------------
         Lock          : Disabled
         Loopback      : Disabled
      ---------------------------------------------------------
        Protection Group Name  : grp1
      ---------------------------------------------------------
         PS Role        : Backup
         PS State       : No Switch
         Peer Tunnel-name: primary
 <=============================================================================>
 P3#sh meh su
 P3#sh meh su
          ^
 % Invalid input detected at '^' marker.
 P3#sh meg summary
 ---------------------MEG-TYPE : IETF------------------------------------------
 MEG-Name             Service-Type    ME-Name              MP Type    Oper-
 Status
 ----------------------MEG-TYPE : ITUT-----------------------------------------
```



```
MEG-Name           Service-Type   MEG-Level          MP-ID     MP Type
Oper-Status
INAIRTEL/meg-2      Tunnel         7                 44         MIP
UP
INAIRTEL/meg-1      Tunnel         7                 4          MIP
UP
INAIRTEL/megd2      Datalink       7                 444        MEP
UP
INAIRTEL/megd3      Datalink       7                 4444       MEP
UP
-----------------------------------------------------------------------
P3#sh itut meg brief
==============================================================================
Maintenance Entity Group  : INAIRTEL/meg-2      MEG Index    : 3
Service Type              : Tunnel              MEG Level    : 7
------------------------------------------------------------------------------
   MP-ID                  : 44                  MP Type      : MIP
   Tunnel Name            : backup              Oper Status  : UP
------------------------------------------------------------------------------
   MP-ID                  : 44                  MP Type      : MIP
   Tunnel Name            : backup              Oper Status  : UP
==============================================================================
Maintenance Entity Group  : INAIRTEL/meg-1      MEG Index    : 2
Service Type              : Tunnel              MEG Level    : 7
------------------------------------------------------------------------------
   MP-ID                  : 4                   MP Type      : MIP
   Tunnel Name            : primary             Oper Status  : UP
   RMEP                   : INAIRTEL/meg-1,6     Direction    : FWD
------------------------------------------------------------------------------
   MP-ID                  : 4                   MP Type      : MIP
   Tunnel Name            : primary             Oper Status  : UP
   RMEP                   : INAIRTEL/meg-1,1     Direction    : REV
==============================================================================
Maintenance Entity Group  : INAIRTEL/megd2      MEG Index    : 1
Service Type              : Datalink            MEG Level    : 7
------------------------------------------------------------------------------
   MP-ID                  : 444
   Provider Interface Name: eth1                Oper Status  : UP
   RMEP                   : INAIRTEL/megd2,3333
------------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 3)
==============================================================================
Maintenance Entity Group  : INAIRTEL/megd3      MEG Index    : 4
Service Type              : Datalink            MEG Level    : 7
------------------------------------------------------------------------------
   MP-ID                  : 4444
   Provider Interface Name: eth4                Oper Status  : UP
   RMEP                   : INAIRTEL/megd3,5555
------------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 3)
P3#sh mpls-tp cc summary
Total number of CC sessions configured : 2
---------------------------------------------------------------------------
MEG-Name            MP-Id          CCM-Interval         Oper status
---------------------------------------------------------------------------
INAIRTEL/megd2      444            3                    Up
INAIRTEL/megd3      4444           3                    Up
```

```
P3#sh mpls ilm-table
Codes: > - selected ILM, p - stale ILM, K - CLI ILM, T - MPLS-TP

Code  In-Label  Out-Label  In-Intf  Out-Intf  Nexthop             FEC
ILM-ID       LSP-Type
 T>   3004      3005      eth3     eth2      ffff.ffff.ffff.0000   N/A
3            LSP_DEFAULT
 T>   1003      1004      eth1     eth4      ffff.ffff.ffff.0000   N/A
1            LSP_DEFAULT
 T>   4002      4003      eth2     eth3      ffff.ffff.ffff.0000   N/A
4            LSP_DEFAULT
 T>   2002      2003      eth4     eth1      ffff.ffff.ffff.0000   N/A
2            LSP_DEFAULT
P3#sh mpls-tp rps protection-group
<=============================================================================>
 Group Name         : grp1            Oper Status       : Up
 Revertive mode     : Revertive
 WTR timer          : 300 sec         Hold-off timer    : 0 sec
 Primary meg        : meg-1           Backup meg        : meg-2
 Primary mip-id     : 4               Backup mip-id     : 44
 Group-Type         : ITUT
---------------------------------------------------------------------------
 Current State      : Idle
 Current Event      : Clear Signal Fail on primary
<===========================================================================>
```

P4

```
P4#sh mpls-tp rps protection-group
<=============================================================================>
 Group Name         : grp1            Oper Status       : Up
 Revertive mode     : Revertive
 WTR timer          : 300 sec         Hold-off timer    : 0 sec
 Primary meg        : meg-1           Backup meg        : meg-2
 Primary mip-id     : 5               Backup mip-id     : 55
 Group-Type         : ITUT
----------------------------------------------------------------------------
 Current State      : Idle
 Current Event      : -
<=============================================================================>
P4#
Vty connection is timed out.
[root@vpc4 sbin]#imish
e
ZebOS-XP version 8.0.0.t14 Archiacanthocephala 06/05/13 09:20:53
P4>en
P4#sh mpls-tp tunnel
<=============================================================================>
 Tunnel-id             : 1              Tunnel-Name         : primary
 Source ICC-Oper-ID    : INAIRTEL       Source Node-Id      : 1.1.1.1
 Destination ICC-Oper-ID: INAIRTEL       Destination Node-Id : 6.6.6.6
 Role   : Transit                       Tunnel Index        : 1
 Mode   : COROUTED(bidirectional)       Tunnel State        : UP
     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 1004             Incoming-Interface  : eth2
       ILM-Index      : 1                Cross-Connect-Index : 1
       Outgoing-Label : 1005             Outgoing-Interface  : eth3
       NHLFE Index    : 1
```

```
        BW-class       : N/A
        Status : UP
      Reverse-Path : ILM   <OPCODE : Swap>
        Incoming-Label : 2001             Incoming-Interface  : eth3
        ILM-Index      : 2                Cross-Connect-Index : 2
        Outgoing-Label : 2002             Outgoing-Interface  : eth2
        NHLFE Index    : 2
        BW-class       : N/A
        Status : UP
      ---------------------------------------------------------
       MEG Index       : 2             ME Index       : 5
      ---------------------------------------------------------
         Lock          : Disabled
         Loopback      : Disabled
      ---------------------------------------------------------
        Protection Group Name  : grp1
      ---------------------------------------------------------
         PS Role        : Primary
         PS State       : No Switch
         Peer Tunnel-name: backup
 <==============================================================================>
 <==============================================================================>
  Tunnel-id            : 2              Tunnel-Name         : backup
  MPLS-TP tunnel type  : Ring tunnel
  Role  : Transit                       Tunnel Index        : 2
  Mode  : COROUTED(bidirectional)       Tunnel State        : UP
      Forward-Path : ILM   <OPCODE : Swap>
        Incoming-Label : 3003             Incoming-Interface  : eth4
        ILM-Index      : 3                Cross-Connect-Index : 3
        Outgoing-Label : 3004             Outgoing-Interface  : eth1
        NHLFE Index    : 3
        BW-class       : N/A
        Status : UP
      Reverse-Path : ILM   <OPCODE : Swap>
        Incoming-Label : 4003             Incoming-Interface  : eth1
        ILM-Index      : 4                Cross-Connect-Index : 4
        Outgoing-Label : 4004             Outgoing-Interface  : eth4
        NHLFE Index    : 4
        BW-class       : N/A
        Status : UP
      ---------------------------------------------------------
       MEG Index       : 1             ME Index       : 55
      ---------------------------------------------------------
         Lock          : Disabled
         Loopback      : Disabled
      ---------------------------------------------------------
        Protection Group Name  : grp1
      ---------------------------------------------------------
         PS Role        : Backup
         PS State       : No Switch
         Peer Tunnel-name: primary
 <=============================================================================>
 P4#sh meg summary
 ------------------------MEG-TYPE : IETF---------------------------------------
 MEG-Name             Service-Type    ME-Name             MP Type    Oper-
 Status
 ------------------------MEG-TYPE : ITUT---------------------------------------
```

```
MEG-Name           Service-Type   MEG-Level          MP-ID     MP Type
Oper-Status
INAIRTEL/meg-2      Tunnel          7                 55         MIP
UP
INAIRTEL/meg-1      Tunnel          7                 5          MIP
UP
INAIRTEL/megd3      Datalink        7                 5555       MEP
UP
----------------------------------------------------------------------------
P4#sh itut meg brief
==============================================================================
Maintenance Entity Group  : INAIRTEL/meg-2      MEG Index    : 1
Service Type              : Tunnel              MEG Level    : 7
------------------------------------------------------------------------------
   MP-ID                  : 55                  MP Type      : MIP
   Tunnel Name            : backup              Oper Status  : UP
------------------------------------------------------------------------------
   MP-ID                  : 55                  MP Type      : MIP
   Tunnel Name            : backup              Oper Status  : UP
==============================================================================
Maintenance Entity Group  : INAIRTEL/meg-1      MEG Index    : 2
Service Type              : Tunnel              MEG Level    : 7
-----------------------------------------------------------------------------
   MP-ID                  : 5                   MP Type      : MIP
   Tunnel Name            : primary             Oper Status  : UP
   RMEP                   : INAIRTEL/meg-1,6     Direction    : FWD
------------------------------------------------------------------------------
   MP-ID                  : 5                   MP Type      : MIP
   Tunnel Name            : primary             Oper Status  : UP
   RMEP                   : INAIRTEL/meg-1,1     Direction    : REV
==============================================================================
Maintenance Entity Group  : INAIRTEL/megd3      MEG Index    : 3
Service Type              : Datalink            MEG Level    : 7
------------------------------------------------------------------------------
   MP-ID                  : 5555
   Provider Interface Name: eth2                Oper Status  : UP
   RMEP                   : INAIRTEL/megd3,4444
-----------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 3)
P4#sh mpls-tp cc summary
Total number of CC sessions configured : 1
------------------------------------------------------------------------------
MEG-Name             MP-Id          CCM-Interval        Oper status
-----------------------------------------------------------------------------
INAIRTEL/megd3       5555           3                   Up
P4#sh mpls ilm-table
Codes: > - selected ILM, p - stale ILM, K - CLI ILM, T - MPLS-TP
Code  In-Label  Out-Label  In-Intf  Out-Intf  Nexthop             FEC
ILM-ID       LSP-Type
 T>   2001      2002       eth3     eth2     ffff.ffff.ffff.0000   N/A
2            LSP_DEFAULT
 T>   1004      1005       eth2     eth3     ffff.ffff.ffff.0000   N/A
1            LSP_DEFAULT
 T>   4003      4004       eth1     eth4     ffff.ffff.ffff.0000   N/A
4            LSP_DEFAULT
 T>   3003      3004       eth4     eth1     ffff.ffff.ffff.0000   N/A
3            LSP_DEFAULT
P4#sh mpls-tp rps protection-group
```



```
<===============================================================================>
 Group Name         : grp1           Oper Status       : Up
 Revertive mode     : Revertive
 WTR timer          : 300 sec        Hold-off timer    : 0 sec
 Primary meg        : meg-1          Backup meg        : meg-2
 Primary mip-id     : 5              Backup mip-id     : 55
 Group-Type         : ITUT
-----------------------------------------------------------------------------
 Current State      : Idle
 Current Event      : -
<===============================================================================>
```

P5

```
P5#sh mpls-tp tunnel
<===============================================================================>
 Tunnel-id              : 2               Tunnel-Name         : backup
 MPLS-TP tunnel type    : Ring tunnel
 Role  : Transit                          Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)          Tunnel State        : UP
     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 3002               Incoming-Interface  : eth2
       ILM-Index      : 1                  Cross-Connect-Index : 1
       Outgoing-Label : 3003               Outgoing-Interface  : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 4004               Incoming-Interface  : eth1
       ILM-Index      : 2                  Cross-Connect-Index : 2
       Outgoing-Label : 4005               Outgoing-Interface  : eth2
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 1              ME Index        : 6
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
<==============================================================================>
P5#sh meg summary
------------------------MEG-TYPE : IETF----------------------------------------
MEG-Name             Service-Type    ME-Name              MP Type    Oper-
Status
------------------------MEG-TYPE : ITUT----------------------------------------
MEG-Name           Service-Type   MEG-Level          MP-ID     MP Type
Oper-Status
INAIRTEL/meg-2      Tunnel         7                  6          MIP
UP
-------------------------------------------------------------------------------
P5#sh itut meg brief
==============================================================================
Maintenance Entity Group  : INAIRTEL/meg-2      MEG Index    : 1
Service Type              : Tunnel              MEG Level    : 7
------------------------------------------------------------------------------
   MP-ID                  : 6                   MP Type      : MIP
   Tunnel Name            : backup              Oper Status  : UP
-------------------------------------------------------------------------------
```

```
    MP-ID                  : 6                   MP Type      : MIP
    Tunnel Name            : backup              Oper Status  : UP
```

P6

```
P6#sh mpls-tp tunnel
<==============================================================================>
 Tunnel-id             : 2                 Tunnel-Name         : backup
 MPLS-TP tunnel type   : Ring tunnel
 Role  : Transit                           Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)           Tunnel State        : UP
     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 3001                Incoming-Interface  : eth2
       ILM-Index      : 1                   Cross-Connect-Index : 1
       Outgoing-Label : 3002                Outgoing-Interface  : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 4005                Incoming-Interface  : eth1
       ILM-Index      : 2                   Cross-Connect-Index : 2
       Outgoing-Label : 4006                Outgoing-Interface  : eth2
       NHLFE Index    : 2
       BW-class       : N/A
       Status : UP
     ---------------------------------------------------------
      MEG Index       : 1               ME Index        : 7
     ---------------------------------------------------------
        Lock          : Disabled
        Loopback      : Disabled
<============================================================================>
P6#wr
Building configuration...
[OK]
P6#
Vty connection is timed out.
[root@vpc6 sbin]#imish
ZebOS-XP version 8.0.0.t14 Archiacanthocephala 06/05/13 09:20:53
P6>en
P6#sh mpls-tp tunnel
<==============================================================================>
 Tunnel-id             : 2                 Tunnel-Name         : backup
 MPLS-TP tunnel type   : Ring tunnel
 Role  : Transit                           Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)           Tunnel State        : UP
     Forward-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 3001                Incoming-Interface  : eth2
       ILM-Index      : 1                   Cross-Connect-Index : 1
       Outgoing-Label : 3002                Outgoing-Interface  : eth1
       NHLFE Index    : 1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Swap>
       Incoming-Label : 4005                Incoming-Interface  : eth1
       ILM-Index      : 2                   Cross-Connect-Index : 2
       Outgoing-Label : 4006                Outgoing-Interface  : eth2
       NHLFE Index    : 2
```

```
         BW-class       : N/A
         Status : UP
       ----------------------------------------------------------
        MEG Index       : 1              ME Index       : 7
       ----------------------------------------------------------
          Lock          : Disabled
          Loopback      : Disabled
<============================================================================>
P6#sh mpls ilm-table
Codes: > - selected ILM, p - stale ILM, K - CLI ILM, T - MPLS-TP

Code  In-Label  Out-Label  In-Intf  Out-Intf  Nexthop             FEC
ILM-ID       LSP-Type
 T>   3001     3002      eth2     eth1      ffff.ffff.ffff.0000   N/A
1            LSP_DEFAULT
 T>   4005     4006      eth1     eth2      ffff.ffff.ffff.0000   N/A
2            LSP_DEFAULT
P6#sh meg summary
------------------------MEG-TYPE : IETF----------------------------------------
MEG-Name             Service-Type    ME-Name              MP Type    Oper-
Status
------------------------MEG-TYPE : ITUT----------------------------------------
MEG-Name           Service-Type   MEG-Level          MP-ID     MP Type
Oper-Status
INAIRTEL/meg-3      Tunnel          7                  7          MIP
UP
-------------------------------------------------------------------------------
P6#sh itut meg brief
============================================================================
Maintenance Entity Group  : INAIRTEL/meg-3      MEG Index    : 1
Service Type              : Tunnel              MEG Level    : 7
------------------------------------------------------------------------
   MP-ID                  : 7                   MP Type      : MIP
   Tunnel Name            : backup              Oper Status  : UP
------------------------------------------------------------------------
   MP-ID                  : 7                   MP Type      : MIP
   Tunnel Name            : backup              Oper Status  : UP
```


CHAPTER 33 MPLS-TP Y.1731 OAM Configuration

This chapter provides configuration examples for ITU-T Y.1731 OAM (Operation, Administration, and Maintenance) which defines protocols and procedures to maintain and diagnose connectivity faults in a maintenance domain.

Proactive OAM

Continuity Checking

This feature applies to tunnel, virtual circuit, and data link configurations. In this example, a corouted tunnel is shown.

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-c`	Configure the MEG name as meg-c.
`(config-itut-meg)#service type tunnel`	Configure the service type as tunnel.
`(config-itut-meg)#mep-id 1`	Configure the MEP identifier as 1.
`(config-itut-mp)#continuity-check interval 1`	Set the continuity check interval to 3.33 milliseconds.
`(config-itut-mp)#rmep-id 4 cc IN icc AIRTEL umc meg-c`	Configure the remote MEP.

PE2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-c`	Configure the MEG name as meg21
`(config-itut-meg)#service type tunnel`	Configure the service type as tunnel
`(config-itut-meg)#mep-id 4`	Configure the MEP identifier as 4
`(config-itut-mp)#continuity-check interval 1`	Set the continuity check interval to 3.33 milliseconds.
`(config-itut-mp)#rmep-id 1 cc IN icc AIRTEL umc meg-c`	Configure the remote MEP.

Validation

PE1

```
#sh itut meg brief
Maintenance Entity Group   : INAIRTEL/meg-c      MEG Index    : 2
Service Type               : Tunnel              MEG Level    : 7
   --------------------------------------------------------------------------
   MP-ID                   : 1                   MP Type      : MEP
   Tunnel Name             : tnl_co              Oper Status  : UP
   RMEP                    : INAIRTEL/meg-c,4

   --------------------------------------------------------------------------
```

```
       Continuity-Check          : Valid (Interval: 1)
#sh mpls-tp cc meg meg-c

   MEG-Name               : INAIRTEL/meg-c
   MP-Id                  : 1

   Oper status            : Up

   CCM-Interval           : 1
   Lowest alarm priority  : 1
   FNG alarm time         : 2.5 seconds
   FNG reset time         : 10 seconds

   All RMEPs are dead     : False
   RDI present            : False

   Fault identified       : False

   RMEP-Id                : 4
   RMEG-Name              : INAIRTEL/meg-c
   RMEP CCM defect        : False
   RMEP last RDI          : False
```

PE2

```
#sh itut meg brief
Maintenance Entity Group  : INAIRTEL/meg-c      MEG Index    : 2
Service Type              : Tunnel              MEG Level    : 7
   ------------------------------------------------------------------------------
   MP-ID                  : 4                   MP Type      : MEP
   Tunnel Name            : tnl_co              Oper Status  : UP
   RMEP                   : INAIRTEL/meg-c,1

   ------------------------------------------------------------------------------
       Continuity-Check          : Valid (Interval: 1)
#sh mpls-tp cc meg meg-c

   MEG-Name               : INAIRTEL/meg-c
   MP-Id                  : 4

   Oper status            : Up

   CCM-Interval           : 1
   Lowest alarm priority  : 1
   FNG alarm time         : 2.5 seconds
   FNG reset time         : 10 seconds

   All RMEPs are dead     : False
   RDI present            : False

   Fault identified       : False

   RMEP-Id                : 1
   RMEG-Name              : INAIRTEL/meg-c
   RMEP CCM defect        : False
   RMEP last RDI          : False
```

Alarm Indication Signal

This feature only applies to tunnel configurations. In this example, the server layer is as OAM data link and the client layer is a co-routed tunnel.

Note: Given below are the server-layer MEP configurations for the data-link server. In order to establish a client-server relationship between the server-layer (data-link layer) and the client-layer (the MPLS-TP tunnel), it is also required to configure the MIP for the tunnel that is configured on P1 and P2.

P1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#interface eth3`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1
`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-d level 5`	Configure the MEG name as meg-d at level 5.
`(config-itut-meg)#service type datalink`	Configure the service type as data link.
`(config-itut-meg)#mep-id 2222`	Configure the MEP identifier as 2222.
`(config-itut-mp)#service datalink eth3`	Associate data link eth3 with the ME.
`(config-itut-mp)#continuity-check interval 2`	Set the continuity check interval to 10 milliseconds. Set continuity checking before enabling AIS in the data link server layer at the transit node.
`(config-itut-mp)#alarm-indication level 7 interval 1`	Enable AIS for client MEG level 7 on the data link server layer at the transit node so that client layer (PE1) is initiated.
`(config-itut-mp)#rmep-id 3333 cc IN icc AIRTEL umc meg-d`	Configure the remote MEP.

P2 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#interface eth2`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1.
`(config)#itut meg meg-d level 5`	Configure the MEG name as meg-d at level 5.
`(config-itut-meg)#service type datalink`	Configure the service type as data link.
`(config-itut-meg)#mep-id 3333`	Configure the MEP identifier as 3333.
`(config-itut-mp)#service datalink eth2`	Associate data link eth3 with the ME.
`(config-itut-mp)#continuity-check interval 2`	Set the continuity check interval to 10 milliseconds. Set continuity checking before enabling AIS in the data link server layer at the transit node.

`(config-itut-mp)#alarm-indication level 7 interval 1`	Enable AIS for client MEG level 7 on the data link server layer at the transit node so that client layer (PE1) is initiated.
`(config-itut-mp)#rmep-id 2222 cc IN icc AIRTEL umc meg-d`	Configure the remote MEP.

Validation

P1

```
#sh itut meg brief
Maintenance Entity Group  : INAIRTEL/meg-d      MEG Index    : 3
Service Type              : Datalink            MEG Level    : 5
   -----------------------------------------------------------------------------
   MP-ID                  : 2222
   Provider Interface Name: eth3                Oper Status  : UP
   RMEP                   : INAIRTEL/meg-d,3333

   -----------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 2)
      Alarm Indication-Signal   : Valid (Refresh Interval: 1 Level :: 7)
```

P2

```
#sh itut meg brief
Maintenance Entity Group  : INAIRTEL/meg-d      MEG Index    : 3
Service Type              : Datalink            MEG Level    : 5
   -----------------------------------------------------------------------------
   MP-ID                  : 3333
   Provider Interface Name: eth2                Oper Status  : UP
   RMEP                   : INAIRTEL/meg-d,2222

   -----------------------------------------------------------------------------
      Continuity-Check          : Valid (Interval: 2)
      Alarm Indication-Signal   : Valid (Refresh Interval: 1 Level :: 7)
```

DefErrorCCM Example

This example shows an improperly configured continuity checking interval at the data link layer that causes an alarm indication signal at the client layer.

P1

```
(config-itut-mp)#continuity-check interval 1 << Configure CCM interval as 1
(config-itut-mp)#exit
#sh mpls-tp cc meg meg-d

   MEG-Name               : INAIRTEL/meg-d
   MP-Id                  : 2222

   Oper status            : Up

   CCM-Interval           : 1
   Lowest alarm priority  : 1
   FNG alarm time         : 2.5 seconds
   FNG reset time         : 10 seconds

   All RMEPs are dead     : True
   RDI present            : True
```

```
    Fault identified       : True
    Fault                  : DefErrorCCM

    Diagnostic message     : CCM interval received does not match
                             the configured CCM interval.

    RMEP-Id                : 3333
    RMEG-Name              : INAIRTEL/meg-d
    RMEP CCM defect        : True
    RMEP last RDI          : Not Applicable
```

PE1

```
 #sh itut meg brief
 Maintenance Entity Group  : INAIRTEL/meg-c      MEG Index    : 2
 Service Type              : Tunnel              MEG Level    : 7
    ---------------------------------------------------------------------------
    MP-ID                  : 1                   MP Type      : MEP
    Tunnel Name            : tnl_co              Oper Status  : UP
    RMEP                   : INAIRTEL/meg-c,4

    ---------------------------------------------------------------------------
       Continuity-Check          : Valid (Interval: 1)
       Remote AIS packet received
```

Loss Measurement

Support to generate and process loss measure (LM) PDUs is not provided in the control plane and must be implemented in hardware.

PE1 (OAM)

#configure terminal	Enter configure mode.
(config)#itut meg meg-c	Configure the MEG name as meg-c.
(config-itut-meg)#service type tunnel	Configure the service type as tunnel.
(config-itut-meg)#mep-id 1	Configure the MEP identifier as 1.
(config-itut-mp)#continuity-check interval 1	Set the continuity check interval to.3.33 milliseconds.
(config-itut-mp)#lm enable	Enable loss measurement.
(config-itut-mp)#rmep-id 4 cc IN icc AIRTEL umc meg-c	Configure the remote MEP.

Validation

PE1

```
 Maintenance Entity Group  : INAIRTEL/meg-c      MEG Index    : 2
 Service Type              : Tunnel              MEG Level    : 7
    ---------------------------------------------------------------------------
    MP-ID                  : 1                   MP Type      : MEP
    Tunnel Name            : tnl_co              Oper Status  : UP
    RMEP                   : INAIRTEL/meg-c,4

    ---------------------------------------------------------------------------
```

```
        Continuity-Check          : Valid (Interval: 1)
        Loss-measurement          : Enabled
    #sh mpls-tp loss-measurement meg-name meg-c mep-id 1

    Codes:
    'Q' - Request not sent,
    'a' - Invalid data format,        'b' - Initialization in progress,
    'c' - Data reset occured,         'd' - Resource temporarily unavailable,
    'e' - Unspecified error,          'f' - Unsupported version,
    'g' - Unsupported control code,   'h' - Unsupported data format,
    'i' - Authentication failure,     'j' - Invalid destination node Id,
    'k' - Connection mismatch,        'l' - Unsupported mandatory TLV,
    'm' - Unsupported query interval, 'n' - Admin block,
    'o' - Resource unavailable,       'p' - Resource released,
    'q' - Invalid message,            'r' - Protocol error

    Q No active loss-measurement session on the ME
```

Lock

This feature only applies to tunnel configurations. In this example, the server layer is as oam data link and the client layer is a corouted tunnel.

`#configure terminal`	Enter configure mode.
`(config)#interface eth3`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1.
`(config-if)exit`	Exit interface mode.
`(config)#itut meg meg-d level 5`	Configure the MEG name as meg-d at level 5.
`(config-itut-meg)#service type datalink`	Configure the service type as data link.
`(config-itut-meg)#mep-id 2222`	Configure the MEP identifier as 2222.
`(config-itut-mp)#service datalink eth3`	Associate data link eth3 with the ME.
`(config-itut-mp)#lock interval 1 level 7`	Enable lock on the data link server layer at transit node so that client layer (PE2) is initiated.
`(config-itut-mp)#rmep-id 3333 cc IN icc AIRTEL umc meg-d`	Configure the remote MEP.

Validation

P1

```
    #sh itut meg brief
    Maintenance Entity Group  : INAIRTEL/meg-d      MEG Index    : 3
    Service Type              : Datalink            MEG Level    : 5
       ----------------------------------------------------------------------------
       MP-ID                  : 2222
       Provider Interface Name: eth3                Oper Status  : UP
       RMEP                   : INAIRTEL/meg-d,3333

       ----------------------------------------------------------------------------
               Lock                       : Valid (Refresh Interval: 1)Maintenance
    Entity Group  :
```


PE1

```
#sh itut meg brief
Maintenance Entity Group  : INAIRTEL/meg-c      MEG Index    : 2
Service Type              : Tunnel              MEG Level    : 7
   ---------------------------------------------------------------------------
   MP-ID                  : 1                   MP Type      : MEP
   Tunnel Name            : tnl_co              Oper Status  : UP
   RMEP                   : INAIRTEL/meg-c,4

   ---------------------------------------------------------------------------
      Remote LOCK packet received
```

One-way and Two-way Delay Measurement

Support to generate and process one-way and two-way delay measurement (1DM and 2DM) PDUs is not provided in the control plane and must be implemented in hardware.

PE1 (OAM)

`#configure terminal`	Enter configure mode.
`(config)#itut meg meg-c`	Configure the MEG name as meg-c.
`(config-itut-meg)#service type tunnel`	Configure the service type as tunnel.
`(config-itut-meg)#mep-id 1`	Configure the MEP identifier as 1.
`(config-itut-mp)#service tunnel tnl_co`	Associate tnl1_co with the ME.
`(config-itut-mp)#1dm interval 4`	Configure one way delay measurement interval to 600 seconds.
`(config-itut-mp)#2dm interval 4`	Configure two way delay measurement interval to 600 seconds.
`(config-itut-mp)#rmep-id 4 cc IN icc AIRTEL umc meg-c`	Configure the remote MEP.

Validation (1DM)

PE1

```
Maintenance Entity Group  : INAIRTEL/meg-c      MEG Index    : 2
Service Type              : Tunnel              MEG Level    : 7
   ---------------------------------------------------------------------------
   MP-ID                  : 1                   MP Type      : MEP
   Tunnel Name            : tnl_co              Oper Status  : UP
   RMEP                   : INAIRTEL/meg-c,4

   ---------------------------------------------------------------------------

      One Way Delay Measurement : Invalid (Reason: OAM operation failed)
#sh mpls-tp delay-measurement meg-name meg-c mep-id 1 1dm

Codes:
'Q' - Request not sent,
'a' - Invalid data format,        'b' - Initialization in progress,
'c' - Data reset occured,         'd' - Resource temporarily unavailable,
'e' - Unspecified error,          'f' - Unsupported version,
```

```
'g' - Unsupported control code,   'h' - Unsupported data format,
'i' - Authentication failure,     'j' - Invalid destination node Id,
'k' - Connection mismatch,        'l' - Unsupported mandatory TLV,
'm' - Unsupported query interval, 'n' - Admin block,
'o' - Resource unavailable,       'p' - Resource released,
'q' - Invalid message,            'r' - Protocol error

Q No active delay-measurement session on the ME
```

Validation (2DM)

PE1

```
Maintenance Entity Group  : INAIRTEL/meg-c      MEG Index    : 2
Service Type              : Tunnel              MEG Level    : 7
   ----------------------------------------------------------------------------
   MP-ID                  : 1                   MP Type      : MEP
   Tunnel Name            : tnl_co              Oper Status  : UP
   RMEP                   : INAIRTEL/meg-c,4

   ----------------------------------------------------------------------------
      Two Way Delay Measurement : Invalid (Reason: OAM operation failed)
#sh mpls-tp delay-measurement meg-name meg-c mep-id 1 2dm

Codes:
'Q' - Request not sent,
'a' - Invalid data format,        'b' - Initialization in progress,
'c' - Data reset occured,         'd' - Resource temporarily unavailable,
'e' - Unspecified error,          'f' - Unsupported version,
'g' - Unsupported control code,   'h' - Unsupported data format,
'i' - Authentication failure,     'j' - Invalid destination node Id,
'k' - Connection mismatch,        'l' - Unsupported mandatory TLV,
'm' - Unsupported query interval, 'n' - Admin block,
'o' - Resource unavailable,       'p' - Resource released,
'q' - Invalid message,            'r' - Protocol error

Q No active delay-measurement session on the ME
```

On-Demand OAM

Loopback

This feature applies to tunnel, virtual circuit, and data link configurations. This example shows a co-routed tunnel.

PE1 (OAM) - Ping to Endpoint

`#ping mpls-tp meg-name meg-c mep-id 1 detail`	Initiates loopback from PE1 to PE2 with meg-c and mepid 1.This is initiated in discovery mode when rmep config is not mentioned.

Validation

```
PE1#sh itut lb-globals meg meg-c 1
Next Seq No           : 6
In-Order Replies      : 5
```



```
Out-Of-Order Replies   : 0
LBR Sent Out           : 0
#ping mpls-tp meg-name meg-c mep-id 1 detail
Discovering MP's on MEG: meg-c, Timeout 5 seconds
! seq_num = 26, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4
! seq_num = 27, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4
! seq_num = 28, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4
! seq_num = 29, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4
! seq_num = 30, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4

Success Rate is 100.00 percent (5/5)

PE2#sh itut lb-globals meg meg-c 4
Next Seq No            : 6
In-Order Replies       : 5
Out-Of-Order Replies   : 0
LBR Sent Out           : 5
PE2#clear itut lb-globals meg meg-c 4
PE2#sh itut lb-globals meg meg-c 4
Next Seq No            : 1
In-Order Replies       : 0
Out-Of-Order Replies   : 0
LBR Sent Out           : 0
```

PE1 (OAM) - Ping to MIP Transit Node

`#ping mpls-tp meg-name meg-c mep-id 1 mip 2 IN AIRTEL meg-c ttl 1 detail`	Initiates loopback from PE1 to P1 (mid node) with meg-c, mepid 1, mipid 2 when rmep configuration is mentioned

Validation

```
PE1#ping mpls-tp meg-name meg-c mep-id 1 mip 2 IN AIRTEL meg-c ttl 1
Initiating lb(CV) on MEG: meg-c, Timeout 5 seconds
 ! ! !
#ping mpls-tp meg-name meg-c mep-id 1 mip 2 IN AIRTEL meg-c ttl 1 detail
Initiating lb(CV) on MEG: meg-c, Timeout 5 seconds
! seq_num = 35, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:2
! seq_num = 36, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:2
! seq_num = 37, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:2
! seq_num = 38, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:2
! seq_num = 39, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:2

Success Rate is 100.00 percent (5/5)
#sh itut lb-globals meg meg-c 1
Next Seq No            : 17
In-Order Replies       : 16
Out-Of-Order Replies   : 0
LBR Sent Out           : 0

PE2#sh itut lb-globals meg meg-c 4
Next Seq No            : 6
In-Order Replies       : 5
Out-Of-Order Replies   : 0
LBR Sent Out           : 11
```

PE1 (OAM)—Ping to Endpoint with TLV option

`#ping mpls-tp meg-name meg-c mep-id 1 rmep 4 IN AIRTEL meg-c detail tlv test-pattern 1 in-service`	Initiates loopback from PE1 to PE2 with meg-c and mepid 1 with test-pattern abc.For out of service testing, the transport path needs to be locked prior starting the loopback.

Validation:

```
#ping mpls-tp meg-name meg-c mep-id 1 rmep 4 IN AIRTEL meg-c detail tlv test-
pattern 1 in-service
Initiating lb(CV) on MEG: meg-c, Timeout 5 seconds
! seq_num = 45, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4
! seq_num = 46, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4
! seq_num = 47, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4
! seq_num = 48, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4
! seq_num = 49, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4

Success Rate is 100.00 percent (5/5)
#ping mpls-tp meg-name meg-c mep-id 1 rmep 4 IN AIRTEL meg-c detail
Initiating lb(CV) on MEG: meg-c, Timeout 5 seconds
! seq_num = 40, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4
! seq_num = 41, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4
! seq_num = 42, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4
! seq_num = 43, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4
! seq_num = 44, cc:IN,  icc:AIRTEL,  umc:/meg-c,  ID:4

Success Rate is 100.00 percent (5/5)
```

Test

This feature applies to tunnel, virtual circuit, and data link configurations. This example shows a co-routed tunnel.

PE1 (OAM) - Ping to Endpoint

`#mpls-tp test meg-name meg-c mep-id 1 in-service test-pattern 1`	Sends 5 test packets to the end point.

Validation:

```
PE1#mpls-tp test meg-name meg-c mep-id 1 in-service test-pattern 1
Initiating test on MEG: meg-c, Duration 5 seconds
 ! ! ! ! !

PE1#sh itut test-globals meg meg-c 1
Meg-Name: meg-c, MP_Id: 1
Test Packet Reception : Enabled
Rx tst packets          : 0
Rx Out-Of-Order Packets : 0
Rx CRC Error Packets    : 0
Rx BER       Packets    : 0

PE2#sh itut test-globals meg meg-c 4
Meg-Name: meg21, MP_Id: 400
Test Packet Reception : Enabled
Rx tst packets          : 5
Rx Out-Of-Order Packets : 0
```



```
Rx CRC Error Packets    : 0
Rx BER       Packets    : 0
```

Loss Measurement

Support to generate and process loss measurement (LM) PDUs is not provided in the control plane and must be implemented in hardware.

PE1 (OAM)

`#mpls-tp lm meg-name meg21 mep-id 100`	Initiates an on-demand delay measurement session for meg21 and mepid 100.

Validation

```
PE1#mpls-tp lm meg-name meg21 mep-id 100
Initiating loss measurement on MEG: meg21, Duration 60 seconds
Q Operation failed
```

One-way and Two-way Delay Measurement

Support to generate and process one-way and two-way delay measurement (1DM and 2DM) PDUs is not provided in the control plane and must be implemented in hardware.

PE1 (OAM)

`#mpls-tp 1dm meg-name meg21 mep-id 100`	Initiates an on-demand delay measurement session for meg21 and mepid 100.
`#mpls-tp 2dm meg-name meg21 mep-id 100`	Initiates an on-demand delay measurement session for meg21 and mepid 100.

Validation

```
PE1#mpls-tp 1dm meg-name meg21 mep-id 100
Initiating delay measurement on MEG: meg21, Duration 60 seconds
Q Operation failed
PE1#mpls-tp 2dm meg-name meg21 mep-id 100
Initiating delay measurement on MEG: meg21, Duration 60 seconds
Q Operation failed
```


CHAPTER 34 MPLS-TP Encapsulation Configurations

This chapter provides configuration examples for the MPLS-TP encapsulation for Raw mode and Tagged mode pseudo wire.

Note: The below configurations is based on using the IETF identifiers. MPLS-TP encapsulation can be configured using the ITUT identifiers as well.

Configuring Raw Mode Pseudo Wire on MPLS-TP Tunnels

This example shows how to configure Raw mode pseudo wire on MPLS-TP tunnels.

Topology

The procedures in this section use the topology in Figure 34-1.

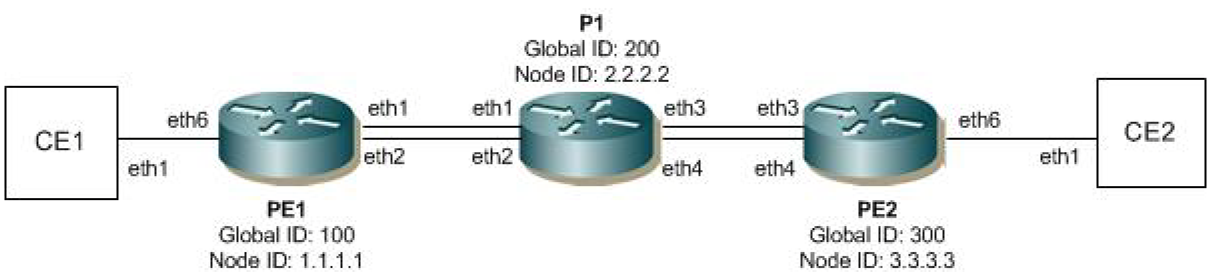


Figure 34-1: MPLS-TP Tunnel Topology (IETF)

PE1

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 100 node-id 1.1.1.1`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as provider and set the local identifier to 10.1.1.1.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path nhlfe-entry 111 eth1 mac 0001.85b8.f011`	Configure forward path.

`(config-bidir-tnl)#reverse-path ilm-entry 444 eth1 pop`	Configure reverse path.
`(config-bidir-tnl)#end`	Exit the tunnel mode.
`#configure terminal`	Enter configure mode.
`(config)#bridge 1 protocol mstp`	Configure bridge
`(config)#mpls l2-circuit vc1 101 300 3.3.3.3 666 grp1 mode raw manual`	Configure PW in raw mode.
`(config)#vlan database`	Enter VLAN database.
`(config-vlan)#vlan 20 bridge 1 state enable`	Configure VLAN 20.
`(config-vlan)#exit`	Exit VLAN database.
`(config)#interface eth6`	Enter interface mode.
`(config-if)#switchport`	Make interface switchport.
`(config-if)#bridge-group 1`	Associate the interface to the bridge.
`(config-if)#switchport mode access`	Make the interface as access port.
`(config-if)#switchport access vlan 20`	Make interface part of VLAN 20.
`(config-if)#mpls-tp service-interface type layer-2 555`	Make interface as MPLS-TP service interface.
`(config-if)#mpls-l2-circuit vc1 ethernet svlan 20 tpid 88a8 action no-op`	Associate PW in raw mode to the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls l2-circuit-fib-entry 101 123 456 tp-tunnel tnl1 eth6`	Configure PW FIB entry.
`(config)#exit`	Exit configure mode.

P1

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 200 node-id 2.2.2.2`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 20.1.1.1.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 20.1.1.2`	Configure the interface eth3 as provider interface and the interface local ID as 20.1.1.2.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel biidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 111 eth1 swap 222 eth3 mac 0010.18dc.45b1`	Configure forward path.

`(config-bidir-tnl)#reverse-path ilm-entry 333 eth3 swap 444 eth1 mac 0010.18ae.d12d`	Configure reverse path.
`(config-bidir-tnl)#end`	Exit the tunnel mode.

PE2

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 300 node-id 3.3.3.3`	Configure the global identifier and node identifier.
`(config)#interface eth3`	Enter interface mode
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 222 eth3 pop`	Configure forward path.
`(config-bidir-tnl)#reverse-path nhlfe-entry 333 eth3 mac 0010.1874.0bfd`	Configure reverse path.
`(config-bidir-tnl)#end`	Exit the tunnel mode.
`#configure terminal`	Enter configure mode.
`(config)#bridge 1 protocol mstp`	Configure bridge
`(config)#mpls l2-circuit vc1 101 100 1.1.1.1 555 grp1 mode raw manual`	Configure PW in raw mode.
`(config)#vlan database`	Enter VLAN database.
`(config-vlan)#vlan 20 bridge 1 state enable`	Configure VLAN 20.
`(config-vlan)#exit`	Exit VLAN database.
`(config)#interface eth6`	Enter interface mode.
`(config-if)#switchport`	Make interface switchport.
`(config-if)#bridge-group 1`	Associate the interface to the bridge.
`(config-if)#switchport mode access`	Make the interface as access port.
`(config-if)#switchport access vlan 20`	Make interface part of VLAN 20.
`(config-if)#mpls-tp service-interface type layer-2 666`	Make interface as MPLS-TP service interface.
`(config-if)#mpls-l2-circuit vc1 ethernet svlan 20 tpid 88a8 action no-op`	Associate PW in raw mode to the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls l2-circuit-fib-entry 101 456 123 tp-tunnel tnl1 eth6`	Configure PW FIB entry.
`(config)#exit`	Exit configure mode.

Validation

```
#show mpls vc-table
VC-ID       Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label
Tunnel-Label  Nexthop          Status
101        20      N/A          eth6          eth1          456       111
N/A              Active

#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: vc1, id: 101  PW-INDEX: 1
 Operating mode: Raw
 Endpoint-Type: MPLS-TP [GlobalID-NodeID]
 Endpoint     : 300-3.3.3.3
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: grp1
 Bound to interface: eth6
 Virtual Circuit Type: Ethernet
 Svlan Id: 20
 Svlan Tpid: 88a8
 Action: no-op
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 PW-Status: Disabled
```

Configuring Tagged Mode Pseudo Wire without Inner VLAN

The following steps describe how to configure Tagged mode pseudo wire without Inner VLAN.

Topology

The procedures in this section use the topology in Figure 34-1.

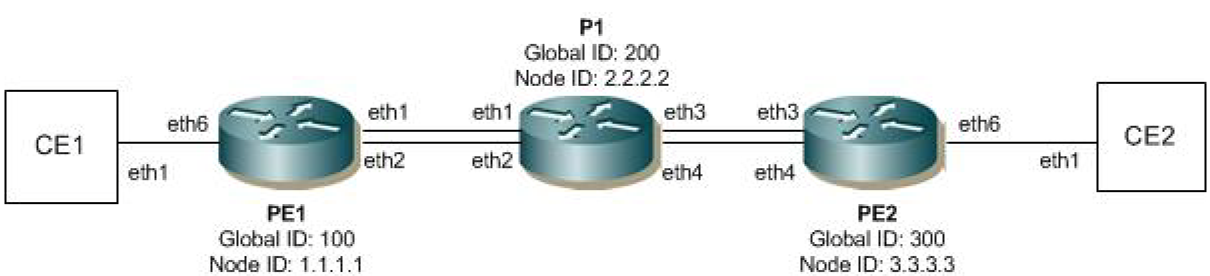


Figure 34-2: MPLS-TP Tunnel Topology (IETF)

PE1

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 100 node-id 1.1.1.1`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode.

(config-if)#mpls-tp provider-interface 10.1.1.1	Configure the interface as provider and set the local identifier to 10.1.1.1.
(config-if)#exit	Exit interface mode.
(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name tnl1	Set the tunnel name.
(config-tnl)#tunnel-mode bidirectional	Make the tunnel bidirectional.
(config-bidir-tnl)#forward-path nhlfe-entry 111 eth1 mac 0001.85b8.f011	Configure forward path.
(config-bidir-tnl)#reverse-path ilm-entry 444 eth1 pop	Configure reverse path.
(config-bidir-tnl)#end	Exit the tunnel mode.
#configure terminal	Enter configure mode.
(config)#bridge 1 protocol mstp	Configure bridge
(config)#mpls l2-circuit vc1 101 300 3.3.3.3 666 grp1 mode tagged svlan 30 tpid 88a8 manual	Configure PW in tagged mode.
(config)#vlan database	Enter VLAN database.
(config-vlan)#vlan 20 bridge 1 state enable	Configure VLAN 20.
(config-vlan)#vlan 30 bridge 1 state enable	Configure VLAN 30.
(config-vlan)#vlan 40 bridge 1 state enable	Configure VLAN 40.
(config-vlan)#exit	Exit VLAN database.
(config)#interface eth6	Enter interface mode.
(config-if)#switchport	Make interface switchport.
(config-if)#bridge-group 1	Associate the interface to the bridge.
(config-if)#switchport mode trunk	Make the interface as trunk port.
(config-if)#switchport trunk allowed vlan all	Make interface part of all the VLAN's configured.
(config-if)#mpls-tp service-interface type layer-2 555	Make interface as MPLS-TP service interface.
(config-if)#mpls-l2-circuit vc1 vlan 20 tpid 88a8 action replace	Associate PW in tagged mode to the interface.
(config-if)#exit	Exit interface mode.
(config)#mpls l2-circuit-fib-entry 101 123 456 tp-tunnel tnl1 eth6	Configure PW FIB entry.
(config)#exit	Exit configure mode.

P1

#configure terminal	Enter configure mode.
(config)#mpls-tp global-id 200 node-id 2.2.2.2	Configure the global identifier and node identifier.
(config)#interface eth1	Enter interface mode.
(config-if)#mpls-tp provider-interface 20.1.1.1	Configure the interface as provider and set the local identifier to 20.1.1.1.

`(config-if)#exit`	Exit interface mode.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 20.1.1.2`	Configure the interface eth3 as provider interface and the interface local ID as 20.1.1.2.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel unidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 111 eth1 swap 222 eth3 mac 0010.18dc.45b1`	Configure forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 333 eth3 swap 444 eth1 mac 0010.18ae.d12d`	Configure reverse path.
`(config-bidir-tnl)#end`	Exit the tunnel mode.

PE2

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 300 node-id 3.3.3.3`	Configure the global identifier and node identifier.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 222 eth3 pop`	Configure forward path.
`(config-bidir-tnl)#reverse-path nhlfe-entry 333 eth3 mac 0010.1874.0bfd`	Configure reverse path.
`(config-bidir-tnl)#end`	Exit the tunnel mode.
`#configure terminal`	Enter configure mode.
`(config)#bridge 1 protocol mstp`	Configure bridge
`(config)#mpls l2-circuit vc1 101 100 1.1.1.1 555 grp1 mode tagged svlan 30 tpid 88a8 manual`	Configure PW in tagged mode.
`(config)#vlan database`	Enter VLAN database.
`(config-vlan)#vlan 30 bridge 1 state enable`	Configure VLAN 30.
`(config-vlan)#vlan 40 bridge 1 state enable`	Configure VLAN 40.
`(config-vlan)#vlan 20 bridge 1 state enable`	Configure VLAN 20.
`(config-vlan)#exit`	Exit VLAN database.
`(config)#interface eth6`	Enter interface mode.

`(config-if)#switchport`	Make interface switchport.
`(config-if)#bridge-group 1`	Associate the interface to the bridge.
`(config-if)#switchport mode trunk`	Make the interface as trunk port.
`(config-if)#switchport trunk allowed vlan all`	Make interface part of all the VLAN's configured..
`(config-if)#mpls-tp service-interface type layer-2 666`	Make interface as MPLS-TP service interface.
`(config-if)#mpls-l2-circuit vc1 vlan 20 tpid 88a8 action replace`	Associate PW in tagged mode to the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls l2-circuit-fib-entry 101 456 123 tp-tunnel tnl1 eth6`	Configure PW FIB entry.
`(config)#exit`	Exit configure mode.

Validation

```
#show mpls vc-table
VC-ID       Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label
Tunnel-Label  Nexthop         Status
101        20      N/A          eth6        eth1           456       111
N/A              Active

#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: vc1, id: 101  PW-INDEX: 1
 Operating mode: Tagged
 Svlan Id: 30
 Svlan Tpid: 88a8
 Endpoint-Type: MPLS-TP [GlobalID-NodeID]
 Endpoint     : 300-3.3.3.3
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: grp1
 Bound to interface: eth6
 Virtual Circuit Type: Ethernet VLAN
 Vlan Id: 20
 Svlan Tpid: 88a8
 Action: replace
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 PW-Status: Disabled
```

Configuring Tagged Mode Pseudo Wire with Inner VLAN

The following steps describe how to configure Tagged mode pseudo wire with Inner VLAN.

PE1

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 100 node-id 1.1.1.1`	Configure the global identifier and node identifier.

`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 10.1.1.1`	Configure the interface as provider and set the local identifier to 10.1.1.1.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path nhlfe-entry 111 eth1 mac 0001.85b8.f011`	Configure forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 444 eth1 pop`	Configure reverse path.
`(config-bidir-tnl)#end`	Exit the tunnel mode.
`#configure terminal`	Enter configure mode.
`(config)#bridge 1 protocol mstp`	Configure bridge
`(config)#mpls l2-circuit vc1 101 300 3.3.3.3 666 grp1 mode tagged svlan 30 tpid 88a8 manual`	Configure PW in tagged mode.
`(config)#vlan database`	Enter VLAN database.
`(config-vlan)#vlan 20 bridge 1 state enable`	Configure VLAN 20.
`(config-vlan)#vlan 30 bridge 1 state enable`	Configure VLAN 30.
`(config-vlan)#vlan 40 bridge 1 state enable`	Configure VLAN 40.
`(config-vlan)#exit`	Exit VLAN database.
`(config)#interface eth6`	Enter interface mode.
`(config-if)#switchport`	Make interface switchport.
`(config-if)#bridge-group 1`	Associate the interface to the bridge.
`(config-if)#switchport mode trunk`	Make the interface as trunk port.
`(config-if)#switchport trunk allowed vlan all`	Make interface part of all the VLAN's configured.
`(config-if)#mpls-tp service-interface type layer-2 555`	Make interface as MPLS-TP service interface.
`(config-if)#mpls-l2-circuit vc1 vlan 20 inner-vlan 50 tpid 88a8 action replace`	Associate PW in tagged mode with inner-VLAN to the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls l2-circuit-fib-entry 101 123 456 tp-tunnel tnl1 eth6`	Configure PW FIB entry.
`(config)#exit`	Exit configure mode.

P1

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 200 node-id 2.2.2.2`	Configure the global identifier and node identifier.
`(config)#interface eth1`	Enter interface mode.

`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 20.1.1.1.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 20.1.1.2`	Configure the interface eth3 as provider interface and the interface local ID as 20.1.1.2.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel unidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 111 eth1 swap 222 eth3 mac 0010.18dc.45b1`	Configure forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 333 eth3 swap 444 eth1 mac 0010.18ae.d12d`	Configure reverse path.
`(config-bidir-tnl)#end`	Exit the tunnel mode.

PE2

`#configure terminal`	Enter configure mode.
`(config)#mpls-tp global-id 300 node-id 3.3.3.3`	Configure the global identifier and node identifier.
`(config)#interface eth3`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 222 eth3 pop`	Configure forward path.
`(config-bidir-tnl)#reverse-path nhlfe-entry 333 eth3 mac 0010.1874.0bfd`	Configure reverse path.
`(config-bidir-tnl)#end`	Exit the tunnel mode.
`#configure terminal`	Enter configure mode.
`(config)#bridge 1 protocol mstp`	Configure bridge
`(config)#mpls l2-circuit vc1 101 100 1.1.1.1 555 grp1 mode tagged svlan 30 tpid 88a8 manual`	Configure PW in tagged mode.
`(config)#vlan database`	Enter VLAN database.
`(config-vlan)#vlan 30 bridge 1 state enable`	Configure VLAN 30.
`(config-vlan)#vlan 40 bridge 1 state enable`	Configure VLAN 40.
`(config-vlan)#vlan 20 bridge 1 state enable`	Configure VLAN 20.

(config-vlan)#exit	Exit VLAN database.
(config)#interface eth6	Enter interface mode.
(config-if)#switchport	Make interface switchport.
(config-if)#bridge-group 1	Associate the interface to the bridge.
(config-if)#switchport mode trunk	Make the interface as trunk port.
(config-if)#switchport trunk allowed vlan all	Make interface part of all the VLAN's configured..
(config-if)#mpls-tp service-interface type layer-2 666	Make interface as MPLS-TP service interface.
(config-if)#mpls-l2-circuit vc1 vlan 40 inner-vlan 60 tpid 88a8 action replace	Associate PW in tagged mode with inner-VLAN to the interface.
(config-if)#exit	Exit interface mode.
(config)#mpls l2-circuit-fib-entry 101 456 123 tp-tunnel tnl1 eth6	Configure PW FIB entry.
(config)#exit	Exit configure mode.

Validation

```
#show mpls vc-table
VC-ID       Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label
Tunnel-Label  Nexthop         Status
101        20      50          eth6          eth1          456       111
N/A              Active

#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: vc1, id: 101  PW-INDEX: 1
 Operating mode: Tagged
 Svlan Id: 30
 Svlan Tpid: 88a8
 Endpoint-Type: MPLS-TP [GlobalID-NodeID]
 Endpoint     : 300-3.3.3.3
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: grp1
 Bound to interface: eth6
 Virtual Circuit Type: Ethernet VLAN
 Vlan Id: 20
 Inner Vlan Id: 50
 Svlan Tpid: 88a8
 Action: replace
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 PW-Status: Disabled
```

CHAPTER 35 MPLS-TP MSPW Configurations

This chapter contains a complete sample of configuring MSPW over MPLS-TP tunnels.

Multi-Segment Pseudo Wires enable a service provider to extend the reach of pseudo-wires across multiple domains. The domains can be autonomous systems under one provider administrative control, IGP areas in one autonomous system, different autonomous systems under the administrative control of two or more service providers, or administratively established pseudowire domains.

The end routers are called Terminating PE routers (T-PEs), and the switching routers are called S-PE routers. The SPE router terminates the tunnels of the preceding and succeeding PW segments in an MS-PW. The S-PE router switches the control and data planes of the preceding and succeeding PW segments of the MS-PW.

An MS-PW is declared to be up when all the single-segment PWs are up.

Configuring MSPW involves three major steps. They are:

- Configuration of Tunnel
- Configuration of Pseudowire
- Stitching the Pseudowire's to form MSPW

Note: The below configurations is based on using the IETF identifiers. MSPW can be configured using the ITUT identifiers as well.

Configuration of IETF Co-Routed Tunnel

The following steps describe how to configure IETF Co-Routed Tunnel.

Topology

The procedures in this section use the topology in Figure 35-1.

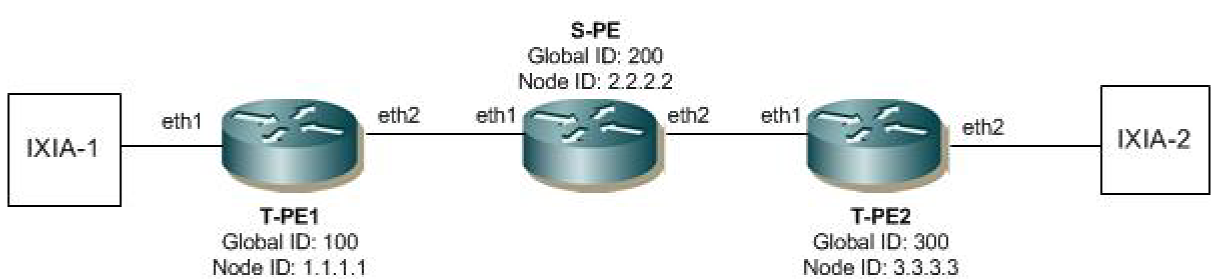


Figure 35-1: MPLS-TP MSPW

T-PE1

`#configure terminal`	Enter configure mode.
`(config)#interface eth2`	Enter interface mode for eth2
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 20.1.1.1.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp global-id 100 node-id 1.1.1.1`	Configure the global identifier and node identifier.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 200 2.2.2.2`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path nhlfe-entry 1000 eth2 mac 0010.1874.0b08`	Configure forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 2000 eth2 pop`	Configure reverse path.
`(config-bidir-tnl)#end`	Exit the tunnel mode.

S-PE

`#configure terminal`	Enter configure mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 20.1.1.2`	Configure the interface as provider and set the local identifier to 20.1.1.2.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode for eth2.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface eth2 as provider interface and the interface local ID as 30.1.1.1.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp global-id 200 node-id 2.2.2.2`	Configure the global identifier and node identifier.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 200 2.2.2.2`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel biidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 1000 eth1 pop`	Configure the ILM entry to pop the label at egress for the forward path.
`(config-bidir-tnl)#reverse-path nhlfe-entry 2000 eth1 mac 0010.1874.0b3e`	Configure the NHLFE entry to push the label at ingress for the reverse path.
`(config-bidir-tnl)#end`	Exit the tunnel mode.
`#configure terminal`	Enter configure mode.

`(config)#mpls-tp tunnel 2 source 200 2.2.2.2 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl2`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path nhlfe-entry 1100 eth2 mac 0010.1874.0b3c`	Configure forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 2100 eth2 pop`	Configure reverse path.
`(config-bidir-tnl)#end`	Exit the tunnel mode.

T-PE2

`#configure terminal`	Enter configure mode.
`(config)#interface eth1`	Enter interface mode for eth1.
`(config-if)#mpls-tp provider-interface 30.1.1.2`	Configure the interface as provider and set the local identifier to 30.1.1.2.
`(config-if)#exit`	Exit interface mode.
`(config)#bridge 1 protocol ieee vlan-bridge`	Configure bridge
`(config)#interface eth2`	Enter interface mode.
`(config-if)#switchport`	Make interface switchport.
`(config-if)#bridge-group 1`	Associate the interface to the bridge.
`(config-if)#switchport mode access`	Make the interface as access port.
`(config-if)#mpls-tp service-interface type layer-2 666`	Make interface as MPLS-TP service interface.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp global-id 300 node-id 3.3.3.3`	Configure the global identifier and node identifier.
`(config)#mpls-tp tunnel 2 source 200 2.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl2`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 1100 eth1 pop`	Configure forward path.
`(config-bidir-tnl)#reverse-path nhlfe-entry 2100 eth1 mac 0010.1874.0b4c`	Configure reverse path.
`(config-bidir-tnl)#end`	Exit the tunnel mode.

Validation

T-PE-1

```
#show mpls-tp tunnel
<================================================================================
=>
```

```
 Tunnel-id              : 1                  Tunnel-Name          : tn1
 Source Global-Id       : 100                Source Node-Id       : 1.1.1.1
 Destination Global-Id : 200                 Destination Node-Id : 2.2.2.2
 Role   : Source                             Tunnel Index         : 1
 Mode   : COROUTED(bidirectional)            Tunnel State         : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1000                  Outgoing-Interface : eth2
       NHLFE Index    : 1                     Nexthop MAC         : 0010.1874.0b3c
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2000                  Incoming-Interface  : eth2
       ILM-Index      : 1                     Cross-Connect-Index : 2
       Status : UP
```

S-PE

```
#show mpls-tp tunnel
<===============================================================================
=>
 Tunnel-id              : 2                  Tunnel-Name          : tn2
 Source Global-Id       : 200                Source Node-Id       : 2.2.2.2
 Destination Global-Id : 300                 Destination Node-Id : 3.3.3.3
 Role   : Source                             Tunnel Index         : 2
 Mode   : COROUTED(bidirectional)            Tunnel State         : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1100                  Outgoing-Interface : eth2
       NHLFE Index    : 2                     Nexthop MAC         : 0010.18dc.45b1
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2100                  Incoming-Interface  : eth2
       ILM-Index      : 2                     Cross-Connect-Index : 1
       Status : UP
<===============================================================================
=>
<===============================================================================
=>
 Tunnel-id              : 1                  Tunnel-Name          : tn1
 Source Global-Id       : 100                Source Node-Id       : 1.1.1.1
 Destination Global-Id : 200                 Destination Node-Id : 2.2.2.2
 Role   : Destination                        Tunnel Index         : 1
 Mode   : COROUTED(bidirectional)            Tunnel State         : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1000                  Incoming-Interface  : eth1
       ILM-Index      : 1                     Cross-Connect-Index : 1
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2000                  Outgoing-Interface : eth1
       NHLFE Index    : 1                     Nexthop MAC         : 0010.1874.0b3e
       BW-class       : N/A
```



```
        Status : UP
<================================================================================
=>
```

T-PE-2

```
#show mpls-tp tunnel
<================================================================================
=>
 Tunnel-id              : 2              Tunnel-Name         : tn2
 Source Global-Id       : 200            Source Node-Id      : 2.2.2.2
 Destination Global-Id  : 300            Destination Node-Id : 3.3.3.3
 Role   : Destination                    Tunnel Index        : 1
 Mode   : COROUTED(bidirectional)        Tunnel State        : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1100              Incoming-Interface  : eth1
       ILM-Index      : 1                 Cross-Connect-Index : 1
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2100              Outgoing-Interface : eth1
       NHLFE Index    : 1                 Nexthop MAC        : 0010.1874.0b4c
       BW-class       : N/A
       Status : UP
<================================================================================
=>
```

Configuration of Pseudowire

After tunnel configuration, pseudowire has to be configured as shown in the following steps.

T-PE1

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit vc1 101 200 2.2.2.2 666 grp1 manual`	Configure Pseudowire for Router 1, with VC1 as Pseudowire name and configure the endpoints. Note: Pseudowire id should be same for both the endpoints.
`(config)#bridge 1 protocol ieee vlan-bridge`	Configure bridge
`(config)#interface eth1`	Enter interface mode.
`(config-if)#switchport`	Make interface switchport.
`(config-if)#bridge-group 1`	Associate the interface to the bridge.
`(config-if)#switchport mode access`	Make the interface as access port.
`(config-if)#mpls-tp service-interface type layer-2 555`	Make interface as MPLS-TP service interface.
`(config-if)##mpls l2-circuit vc1 ethernet`	Bind the Pseudowire with the access interface of Edge node router.
`(config-if)#exit`	Exit interface mode.

(config)#mpls l2-circuit-fib-entry 101 100 200 tp-tunnel tn1 eth1	Configure the FIB entry for the configured Pseudowire.
(config)#exit	Exit configure mode.

S-PE

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit vc1 101 100 1.1.1.1 555 grp1 manual	Configure Pseudowire for Router 2, with VC1 as Pseudowire name and configure the endpoints Note: Pseudowire id should be same for both the endpoints.
(config)#mpls l2-circuit vc2 102 300 3.3.3.3 666 grp1 manual	Configure another Pseudowire for Router 2, with VC2 as Pseudowire name and configure the endpoints.
(config)#exit	Exit configure mode.

T-PE2

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit vc2 101 200 2.2.2.2 666 grp1 manual	Configure Pseudowire for Router 3, with VC2 as Pseudowire name and configure the endpoints. Note: Pseudowire id should be same for both the endpoints.
(config)#bridge 1 protocol ieee vlan-bridge	Configure bridge
(config)#interface eth1	Enter interface mode.
(config-if)#switchport	Make interface switchport.
(config-if)#bridge-group 1	Associate the interface to the bridge.
(config-if)#switchport mode access	Make the interface as access port.
(config-if)#mpls-tp service-interface type layer-2 666	Make interface as MPLS-TP service interface.
(config-if)##mpls l2-circuit vc2 ethernet	Bind the Pseudowire with the access interface of Edge node router.
(config-if)#exit	Exit interface mode.
(config)#mpls l2-circuit-fib-entry 101 120 220 tp-tunnel tn2 eth1	Configure the FIB entry for the configured Pseudowire.
(config)#exit	Exit configure mode.

Validation

T-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/Aeth2        eth1          52488     52482         68.68.68.68
Active
20     N/A     N/A eth2        eth1          52480     52484         69.69.69.69
Standby
```


S-PE

```
#show mpls vc-table
VC-ID        Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label
Tunnel-Label  Nexthop         Status
101          N/A      N/A            eth2           eth1           100
2000           N/A            Active
102          N/A      N/A            eth1           eth2           210
1100           N/A            Active
```

T-PE2

```
#show mpls vc-table
VC-ID        Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label
Tunnel-Label  Nexthop         Status
102          N/A      N/A            eth1           eth2           110
2100           N/A            Active
```

Configuration of MSPW

After configuring tunnels and pseudowire's, stitching can be done at the transit node (or) stitching node, by using the steps as shown below:

S-PE

`#configure terminal`	Enter configure mode.
`(config)#mpls ms-pw-stitch sp1 vc1 vc2`	Stitch the two pseudowires on router2.
`(config)#mpls l2-circuit-fib-entry 101 200 100 tp-tunnel tn1 vc2`	Configure the FIB entry for the configured Pseudowire.
`(config)#mpls l2-circuit-fib-entry 102 110 210 tp-tunnel tn2 vc1`	Configure the FIB entry for the configured Pseudowire.
`(config)#exit`	Exit configure mode.

Validation

S-PE

```
#show mpls ms-pw
MS-PW  VC_TYPE  Segment-1  VC1-ID  Segment-2  VC2-ID
sp1    MPLS-TP     vc1      101       vc2        102

#show mpls ms-pw sp1
MS-PW Status: UP
VC1:              vc1       VC2:            vc2
id:               101       id:             102
Status:           UP        Status:            UP
Endpoint:         1.1.1.1   Endpoint:       3.3.3.3
Control Word:     0         Control Word:   0
VC Type:          Ethernet  VC Type:        Ethernet
Owner:            Manual    Owner:          Manual
Role:             Active    Role:           Active
```



```
#show mpls ms-pw sp1 vc-table
In VC    vlan-id         in-lbl  nw-intf         out-lbl         status
tunnel-lbl
vc1      N/A             200     eth1            210             Active
1100
vc2      N/A             110     eth2            100             Active
2000
```


CHAPTER 36 MPLS-TP VPLS Configurations

Virtual Private LAN Services (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 pseudo-wires. It uses a set of Martini circuits grouped by a common VPLS identifier to achieve this service objective. VPLS supports topologies like peer and spoke, where peer consists of full mesh VPLS pseudo wires in MPLS core and spokes consist of L3 tunnels connecting to VPLS LER's (Peer).

The following steps are used to configure VPLS. They are:

- Configuration of MPLS-TP Tunnels
- Configuration of VPLS instances, peer and FIB entries.

Note: The below configurations is based on using the IETF identifiers. VPLS/HVPLS can be configured using the ITUT identifiers as well.

Configuration of Tunnel

The following steps describe how to configure IETF Co-routed tunnel.

Topology

The procedures in this section use the topology in Figure 36-1.

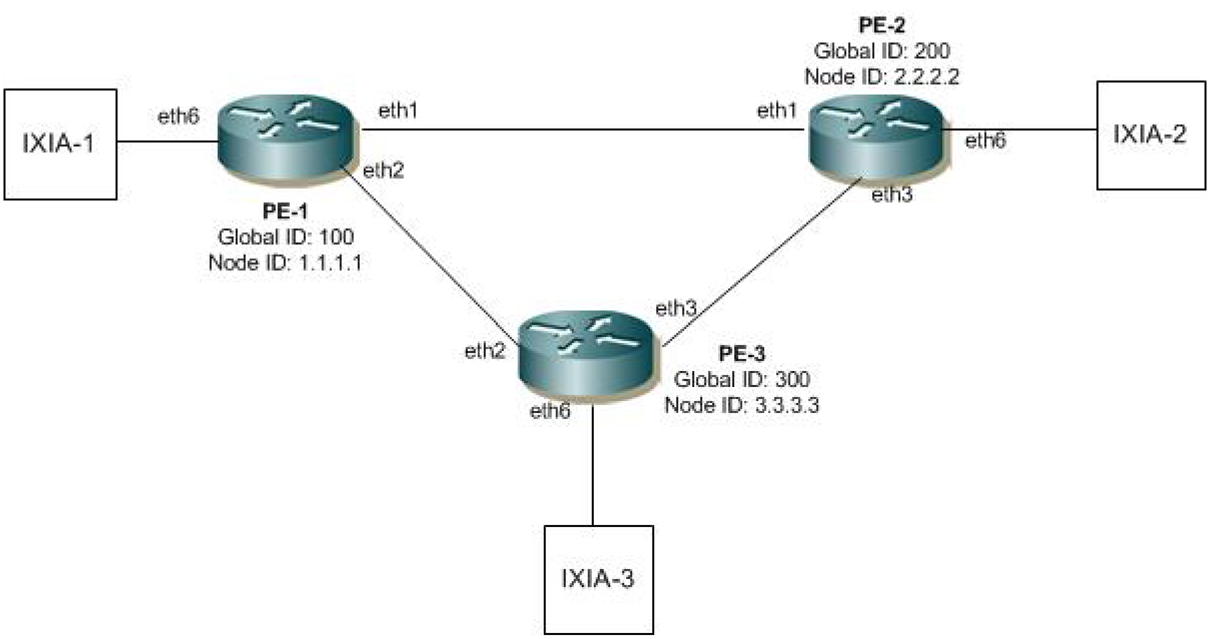


Figure 36-1: MPLS-TP VPLS

PE-1

`#configure terminal`	Enter configure mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 20.1.1.1`	Configure the interface as provider and set the local identifier to 20.1.1.1.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 30.1.1.1`	Configure the interface as provider and set the local identifier to 30.1.1.1.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 200 2.2.2.2`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl1`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path nhlfe-entry 1000 eth1 mac 0010.1874.0b08`	Configure the NHLFE entry to push the label at ingress for the forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 2000 eth1 pop`	Configure the ILM entry to pop the label at egress for the reverse path.
`(config-bidir-tnl)#exit`	Exit tunnel-entry configuration mode.
`(config-tnl)#exit`	Exit tunnel mode.
`(config)#mpls-tp tunnel 2 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl2`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path nhlfe-entry 1100 eth2 mac 0010.1874.0b09`	Configure the NHLFE entry to push the label at ingress for the forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 2100 eth2 pop`	Configure the ILM entry to pop the label at egress for the reverse path.
`(config-bidir-tnl)#exit`	Exit tunnel-entry configuration mode.
`(config-tnl)#exit`	Exit tunnel mode.
`(config)#exit`	Exit configure mode

PE-2

`#configure terminal`	Enter configure mode.
`(config)#interface eth1`	Enter interface mode.
`(config-if)#mpls-tp provider-interface 20.1.1.2`	Configure the interface as provider and set the local identifier to 20.1.1.2.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth3`	Enter interface mode.

(config-if)#mpls-tp provider-interface 40.1.1.1	Configure the interface as provider and set the local identifier to 40.1.1.1.
(config-if)#exit	Exit interface mode.
(config)#mpls-tp global-id 200 node-id 2.2.2.2	Configure the global identifier and node identifier.
(config)#mpls-tp tunnel 1 source 100 1.1.1.1 destination 200 2.2.2.2	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name tnl1	Set the tunnel name.
(config-tnl)#tunnel-mode bidirectional	Make the tunnel bidirectional.
(config-bidir-tnl)#forward-path ilm-entry 1000 eth1 pop	Configure the NHLFE entry to push the label at egress for the forward path.
(config-bidir-tnl)#reverse-path nhlfe-entry 2000 eth1 mac 0010.1874.0b3e	Configure the ILM entry to pop the label at ingress for the reverse path.
(config-bidir-tnl)#exit	Exit tunnel-entry configuration mode.
(config-tnl)#exit	Exit tunnel mode.
(config)#mpls-tp tunnel 3 source 200 2.2.2.2 destination 300 3.3.3.3	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name tnl3	Set the tunnel name.
(config-tnl)#tunnel-mode bidirectional	Make the tunnel bidirectional.
(config-bidir-tnl)#forward-path nhlfe-entry 1200 eth3 mac 0010.1874.0b3c	Configure the NHLFE entry to push the label at ingress for the forward path.
(config-bidir-tnl)#reverse-path ilm-entry 2200 eth3 pop	Configure the ILM entry to pop the label at egress for the reverse path.
(config-bidir-tnl)#exit	Exit tunnel-entry configuration mode.
(config-tnl)#exit	Exit tunnel mode.
(config)#exit	Exit configure mode

PE-3

#configure terminal	Enter configure mode.
(config)#interface eth2	Enter interface mode.
(config-if)#mpls-tp provider-interface 30.1.1.2	Configure the interface as provider and set the local identifier to 30.1.1.2.
(config-if)#exit	Exit interface mode.
(config)#interface eth3	Enter interface mode.
(config-if)#mpls-tp provider-interface 40.1.1.2	Configure the interface as provider and set the local identifier to 40.1.1.2
(config-if)#exit	Exit interface mode.
(config)#mpls-tp global-id 300 node-id 3.3.3.3	Configure the global identifier and node identifier.
(config)#mpls-tp tunnel 3 source 200 2.2.2.2 destination 300 3.3.3.3	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
(config-tnl)#tunnel-name tnl2	Set the tunnel name.

`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 1200 eth3 pop`	Configure the NHLFE entry to push the label at egress for the forward path.
`(config-bidir-tnl)#reverse-path nhlfe-entry 2200 eth3 mac 0010.1874.0b4c`	Configure the ILM entry to pop the label at ingress for the reverse path.
`(config-bidir-tnl)#exit`	Exit tunnel-entry configuration mode.
`(config-tnl)#exit`	Exit tunnel mode.
`(config)#mpls-tp tunnel 2 source 100 1.1.1.1 destination 300 3.3.3.3`	Configure the tunnel identifier, the source global identifier and node identifier, and the destination global identifier and node identifier.
`(config-tnl)#tunnel-name tnl2`	Set the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Make the tunnel bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 1100 eth2 pop`	Configure the NHLFE entry to push the label at egress for the forward path.
`(config-bidir-tnl)#reverse-path nhlfe-entry 2100 eth1 mac 0010.1874.0b4d`	Configure the ILM entry to pop the label at ingress for the reverse path.
`(config-bidir-tnl)#exit`	Exit tunnel-entry configuration mode.
`(config-tnl)#exit`	Exit tunnel mode.
`(config)#exit`	Exit configure mode

Validation

PE-1

```
#show mpls-tp tunnel
<==============================================================================
=>
 Tunnel-id              : 1                 Tunnel-Name          : tn1
 Source Global-Id       : 100               Source Node-Id       : 1.1.1.1
 Destination Global-Id : 200                Destination Node-Id : 2.2.2.2
 Role   : Source                            Tunnel Index         : 1
 Mode   : COROUTED(bidirectional)           Tunnel State         : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1000                 Outgoing-Interface : eth1
       NHLFE Index    : 1                    Nexthop MAC        : 0010.1874.0b08
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2000                 Incoming-Interface  : eth1
       ILM-Index      : 1                    Cross-Connect-Index : 2
       Status : UP
<==============================================================================
=>
<==============================================================================
=>
 Tunnel-id              : 2                 Tunnel-Name          : tn2
 Source Global-Id       : 100               Source Node-Id       : 1.1.1.1
 Destination Global-Id : 300                Destination Node-Id : 3.3.3.3
 Role   : Source                            Tunnel Index         : 2
 Mode   : COROUTED(bidirectional)           Tunnel State         : UP
```



```
      Forward-Path : NHLFE   <OPCODE : Push>
        Outgoing-Label : 1100              Outgoing-Interface : eth2
        NHLFE Index    : 2                 Nexthop MAC        : 0010.1874.0b09
        BW-class       : N/A
        Status : UP
      Reverse-Path : ILM   <OPCODE : Pop>
        Incoming-Label : 2200              Incoming-Interface  : eth2
        ILM-Index      : 2                 Cross-Connect-Index : 2
        Status : UP
<===============================================================================
=>
```

PE-2

```
#show mpls-tp tunnel
<===============================================================================
=>
 Tunnel-id             : 3               Tunnel-Name         : tn3
 Source Global-Id      : 200             Source Node-Id      : 2.2.2.2
 Destination Global-Id : 300             Destination Node-Id : 3.3.3.3
 Role  : Source                          Tunnel Index        : 2
 Mode  : COROUTED(bidirectional)         Tunnel State        : UP


      Forward-Path : NHLFE   <OPCODE : Push>
        Outgoing-Label : 1200              Outgoing-Interface : eth3
        NHLFE Index    : 2                 Nexthop MAC        : 0010.1874.0b3c
        BW-class       : N/A
        Status : UP
      Reverse-Path : ILM   <OPCODE : Pop>
        Incoming-Label : 2200              Incoming-Interface  : eth3
        ILM-Index      : 2                 Cross-Connect-Index : 1
        Status : UP
<===============================================================================
=>
<===============================================================================
=>
 Tunnel-id             : 1               Tunnel-Name         : tn1
 Source Global-Id      : 100             Source Node-Id      : 1.1.1.1
 Destination Global-Id : 200             Destination Node-Id : 2.2.2.2
 Role  : Destination                     Tunnel Index        : 1
 Mode  : COROUTED(bidirectional)         Tunnel State        : UP


      Forward-Path : ILM   <OPCODE : Pop>
        Incoming-Label : 1000              Incoming-Interface  : eth1
        ILM-Index      : 1                 Cross-Connect-Index : 1
        Status : UP
      Reverse-Path : NHLFE   <OPCODE : Push>
        Outgoing-Label : 2000              Outgoing-Interface : eth1
        NHLFE Index    : 1                 Nexthop MAC        : 0010.1874.0b3e
        BW-class       : N/A
        Status : UP
<===============================================================================
=>
```

PE-3

```
#show mpls-tp tunnel
<================================================================================
=>
 Tunnel-id             : 2                Tunnel-Name          : tn2
 Source Global-Id      : 100              Source Node-Id       : 1.1.1.1
 Destination Global-Id : 300              Destination Node-Id : 3.3.3.3
 Role  : Destination                      Tunnel Index         : 1
 Mode  : COROUTED(bidirectional)          Tunnel State         : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1100               Incoming-Interface  : eth2
       ILM-Index      : 1                  Cross-Connect-Index : 1
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2100               Outgoing-Interface : eth2
       NHLFE Index    : 1                  Nexthop MAC        : 0010.1874.0b4c
       BW-class       : N/A
       Status : UP
<================================================================================
=>
<================================================================================
=>
 Tunnel-id             : 3                Tunnel-Name          : tn3
 Source Global-Id      : 200              Source Node-Id       : 2.2.2.2
 Destination Global-Id : 300              Destination Node-Id : 3.3.3.3
 Role  : Destination                      Tunnel Index         : 2
 Mode  : COROUTED(bidirectional)          Tunnel State         : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1200               Incoming-Interface  : eth3
       ILM-Index      : 2                  Cross-Connect-Index : 1
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2200               Outgoing-Interface : eth3
       NHLFE Index    : 2                  Nexthop MAC        : 0010.1874.0b4d
       BW-class       : N/A
       Status : UP
<================================================================================
=>
```

Configuration of VPLS

After tunnel configuration, VPLS has to be configured as shown in the following steps.

PE-1

`#configure terminal`	Enter configure mode.
`(config)#mpls vpls vpls1 1`	Configure the VPLS instance.
`(config-vpls)#vpls-peer 2.2.2.2 global-id 200 tunnel-name tn1 manual`	Configure the VPLS peer.

(config-vpls)#vpls-peer 3.3.3.3 global-id 300 tunnel-name tn2 manual	Configure the VPLS peer.
(config-vpls)#exit	Exit the VPLS mode.
(config)#bridge 1 protocol ieee vlan-bridge	Enter interface mode.
(config)#interface eth6	Enter interface mode.
(config-if)#switchport	Switch to Layer-2 mode. (MPLS l2 circuit can be bound only on the Layer-2 port.)
(config)#bridge-group 1	Configure bridge-group
(config)#switchport mode access	Configure switchport mode as access
(config-if)#mpls-vpls vpls1 Ethernet	Bind the interface with VPLS.
(config-if)#exit	Exit interface mode.
(config)#vpls fib-entry 1 peer 2.2.2.2 200 eth1 100	Configure the FIB entry for the configured VPLS instance.
(config)#vpls fib-entry 1 peer 3.3.3.3 220 eth2 120	Configure the FIB entry for the configured VPLS instance.
(config)#exit	Exit configure mode

PE-2

#configure terminal	Enter configure mode.
(config)#mpls vpls vpls1 1	Configure the VPLS instance.
(config-vpls)#vpls-peer 1.1.1.1 global-id 100 tunnel-name tn1 manual	Configure the VPLS peer.
(config-vpls)#vpls-peer 3.3.3.3 global-id 300 tunnel-name tn3 manual	Configure the VPLS peer.
(config-vpls)#exit	Exit the VPLS mode.
(config)#bridge 1 protocol ieee vlan-bridge	Enter interface mode.
(config)#interface eth6	Enter interface mode.
(config-if)#switchport	Switch to Layer-2 mode. (MPLS l2 circuit can be bound only on the Layer-2 port.)
(config)#bridge-group 1	Configure bridge-group
(config)#switchport mode access	Configure switchport mode as access
(config-if)#mpls-vpls vpls1 Ethernet	Bind the interface with VPLS.
(config-if)#exit	Exit interface mode.
(config)#vpls fib-entry 1 peer 1.1.1.1 100 eth1 200	Configure the FIB entry for the configured VPLS instance.
(config)#vpls fib-entry 1 peer 3.3.3.3 210 eth3 110	Configure the FIB entry for the configured VPLS instance.
(config)#exit	Exit configure mode

PE-3

`#configure terminal`	Enter configure mode.
`(config)#mpls vpls vpls1 1`	Configure the VPLS instance.
`(config-vpls)#vpls-peer 1.1.1.1 global-id 100 tunnel-name tn2 manual`	Configure the VPLS peer.
`(config-vpls)#vpls-peer 2.2.2.2 global-id 200 tunnel-name tn3 manual`	Configure the VPLS peer.
`(config-vpls)#exit`	Exit the VPLS mode.
`(config)#bridge 1 protocol ieee vlan-bridge`	Enter interface mode.
`(config)#interface eth6`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode. (MPLS l2 circuit can be bound only on the Layer-2 port.)
`(config)#bridge-group 1`	Configure bridge-group
`(config)#switchport mode access`	Configure switchport mode as access
`(config-if)#mpls-vpls vpls1 Ethernet`	Bind the interface with VPLS.
`(config-if)#exit`	Exit interface mode.
`(config)#vpls fib-entry 1 peer 1.1.1.1 120 eth2 220`	Configure the FIB entry for the configured VPLS instance.
`(config)#vpls fib-entry 1 peer 2.2.2.2 110 eth3 210`	Configure the FIB entry for the configured VPLS instance.
`(config)#exit`	Exit configure mode

Validation

PE-1

```
#show mpls vpls detail
Virtual Private LAN Service Instance: vpls1, ID: 1
 SIG-Protocol: STATIC
 Learning: Enabled
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 Operating mode: Raw
 Configured interfaces:
 none
 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
1          2.2.2.2          1000          200        eth1            100
0/Up      1         STATIC
1          3.3.3.3          1200          220        eth2            120
0/Up      2         STATIC

#show vpls vpls1 mac-address
MAC address      Learned from    Peer address
00 00 0B 00 05 00    eth6            -
```

PE-2

```
#show mpls vpls detail
Virtual Private LAN Service Instance: vpls1, ID: 1
 SIG-Protocol: STATIC
 Learning: Enabled
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 Operating mode: Raw
 Configured interfaces:
 none
 Mesh Peers:  1.1.1.1 (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
1          1.1.1.1          2000          100        eth1           200
0/Up      1         STATIC
1          3.3.3.3          1200          210        eth2           110
0/Up      2         STATIC

#show vpls vpls1 mac-address
MAC address      Learned from    Peer address
00 00 0B 00 05 00    eth1         1.1.1.1
```

PE-3

```
#show mpls vpls detail
Virtual Private LAN Service Instance: vpls1, ID: 1
 SIG-Protocol: STATIC
 Learning: Enabled
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 Operating mode: Raw
 Configured interfaces:
 none
 Mesh Peers:  2.2.2.2 (Up)
              1.1.1.1 (Up)

#show mpls vpls mesh
VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX  SIG-Protocol
1          2.2.2.2          2200          110        eth3           210
0/Up      1         STATIC
1          1.1.1.1          2100          120        eth2           220
0/Up      2         STATIC

#show vpls vpls1 mac-address
MAC address      Learned from    Peer address
00 00 0B 00 05 00    eth2            1.1.1.1
```

Configuration of HVPLS

In HVPLS, a spoke node can be added directly to the previous VPLS configuration using the sample configuration given below.

Topology

The procedures in this section use the topology in Figure 36-2

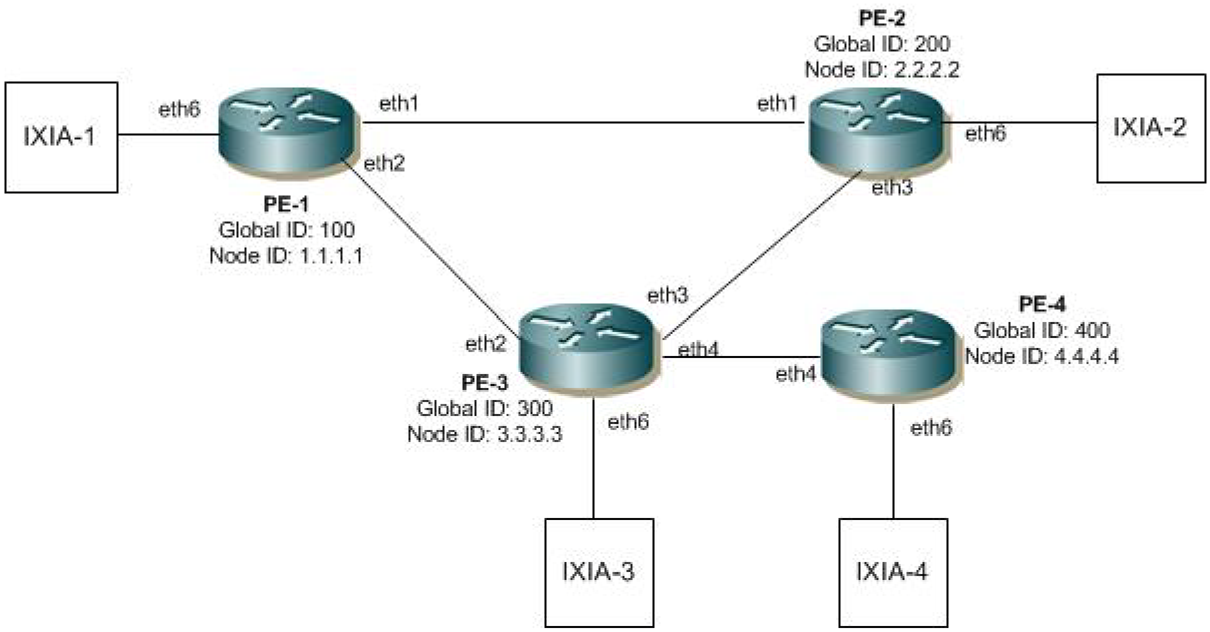


Figure 36-2: MPLS-TP HVPLS

Note: PE-4 is the MTU-s (Spoke node)

PE-3

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit vc1 101 400 4.4.4.4 666 grp1 manual`	Configure a Virtual Circuitr (VC) for the spoke node.
`(config)#mpls-tp tunnel 4 source 300 3.3.3.3 destination 400 4.4.4.4`	Configure the tunnel using the source and destination identifiers.
`(config-tnl)#tunnel-name tn4`	Specify the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Configure the tunnel mode as bidirectional.
`(config-bidir-tnl)#forward-path nhlfe-entry 1300 eth4 mac 0010.1874.0b4c`	Configure the NHLFE entry to push the label at ingress for the forward path.
`(config-bidir-tnl)#reverse-path ilm-entry 2300 eth4 pop`	Configure the ILM entry to pop the label at egress for the reverse path.
`(config-bidir-tnl)#exit`	Exit the tunnel-entry configuration mode.

`(config-tnl)#exit`	Exit the tunnel mode
Note: For both bridge and non-bridge capable spoke, VPLS has to be configured in hub	
`(config)#mpls vpls vpls1 1`	Configure the VPLS instance.
`(config-vpls)#vpls-vc vc1 ethernet tunnel-name tn4`	Bind the VC to VPLS
`(config-vpls)#exit`	Exit the VPLS mode
`(config)#vpls fib-entry 1 spoke-vc vc1 240 eth4 140`	Configure FIB entry for the spoke-VC.
`(config)#exit`	Exit configure mode.

PE-4

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit vc1 101 300 3.3.3.3 555 grp1 manual`	Configure a Virtual Circuitr (VC) for the spoke node.
`(config)#mpls-tp tunnel 4 source 300 3.3.3.3 destination 400 4.4.4.4`	Configure the tunnel using the source and destination identifiers.
`(config-tnl)#tunnel-name tn4`	Specify the tunnel name.
`(config-tnl)#tunnel-mode bidirectional`	Configure the tunnel mode as bidirectional.
`(config-bidir-tnl)#forward-path ilm-entry 1300 eth4 pop`	Configure the ILM entry to pop the label at egress for the forward path.
`(config-bidir-tnl)#reverse-path nhlfe-entry 2300 eth4 mac 0010.1874.0b4e`	Configure the NHLFE entry to push the label at ingress for the reverse path.
`(config-bidir-tnl)#exit`	Exit the tunnel-entry configuration mode.
`(config-tnl)#exit`	Exit the tunnel mode
Note: Following configurations has to be made for bridge capable spoke	
`(config)#mpls vpls vpls1 1`	Configure the VPLS instance.
`(config-vpls)#vpls-vc vc1 ethernet tunnel-name tn4`	Bind the VC to VPLS
`(config-vpls)#exit`	Exit the VPLS mode
`(config)#vpls fib-entry 1 spoke-vc vc1 140 eth4 240`	Configure FIB entry for the spoke-VC.
`(config)#exit`	Exit configure mode.
`(config)#bridge 1 protocol ieee vlan-bridge`	Enter interface mode.
`(config)#interface eth6`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode. (MPLS l2 circuit can be bound only on the Layer-2 port.)
`(config)#bridge-group 1`	Configure bridge-group
`(config)#switchport mode access`	Configure switchport mode as access
`(config-if)#mpls-vpls vpls1 Ethernet`	Bind the interface with VPLS.
`(config-if)#exit`	Exit interface mode.

Note: Following configurations has to be made for non-bridge capable spoke	
`(config)#mpls l2-circuit-fib-entry 101 140 240 tp-tunnel tn4 eth6`	Configured the FIB entry for the configured VC.
`(config)#interface eth6`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode. (MPLS l2 circuit can be bound only on the Layer-2 port.)
`(config)#bridge-group 1`	Configure bridge-group
`(config)#switchport mode access`	Configure switchport mode as access
`(config-if)#mpls-tp service-interface type layer-2 666`	Configure the interface as service interface.
`(config-if)#mpls-l2-circuit vc1 ethernet`	Bind the VC with the access interface.
`(config-if)#exit`	Exit interface mode.
`(config)#exit`	Exit configure mode.

Validation

PE-3

```
#show mpls-tp tunnel
<==============================================================================
=>
 Tunnel-id              : 4                Tunnel-Name          : tn4
 Source Global-Id       : 300              Source Node-Id       : 3.3.3.3
 Destination Global-Id : 400               Destination Node-Id : 4.4.4.4
 Role   : Source                           Tunnel Index         : 3
 Mode   : COROUTED(bidirectional)          Tunnel State         : UP


     Forward-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 1300               Outgoing-Interface : eth4
       NHLFE Index    : 3                  Nexthop MAC        : 0010.1874.0b4c
       BW-class       : N/A
       Status : UP
     Reverse-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 2300               Incoming-Interface  : eth4
       ILM-Index      : 3                  Cross-Connect-Index : 1
       Status : UP
<==============================================================================
=>
<==============================================================================
=>
 Tunnel-id              : 2                Tunnel-Name          : tn2
 Source Global-Id       : 100              Source Node-Id       : 1.1.1.1
 Destination Global-Id : 300               Destination Node-Id : 3.3.3.3
 Role   : Destination                      Tunnel Index         : 1
 Mode   : COROUTED(bidirectional)          Tunnel State         : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1100               Incoming-Interface  : eth2
       ILM-Index      : 1                  Cross-Connect-Index : 1
       Status : UP
```



```
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2100             Outgoing-Interface : eth2
       NHLFE Index    : 1                Nexthop MAC        : 0010.1874.0b4c
       BW-class       : N/A
       Status : UP
<==============================================================================
=>
<==============================================================================
=>
 Tunnel-id             : 3               Tunnel-Name         : tn3
 Source Global-Id      : 200             Source Node-Id      : 2.2.2.2
 Destination Global-Id : 300             Destination Node-Id : 3.3.3.3
 Role  : Destination                     Tunnel Index        : 2
 Mode  : COROUTED(bidirectional)         Tunnel State        : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1200              Incoming-Interface  : eth3
       ILM-Index      : 2                 Cross-Connect-Index : 1
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2200             Outgoing-Interface : eth3
       NHLFE Index    : 2                Nexthop MAC        : 0010.1874.0b4d
       BW-class       : N/A
       Status : UP
<==============================================================================
=>

#show mpls vpls detail
Virtual Private LAN Service Instance: vpls1, ID: 1
 SIG-Protocol: STATIC
 Learning: Enabled
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 Operating mode: Raw
 Configured interfaces:
 none
 Mesh Peers:  1.1.1.1 (Up)
              2.2.2.2 (Up)
 Spoke Peers: vc1 (Up)

#show mpls vpls spoke
VPLS-ID    Virtual Circuit  Tunnel-Label In-Label   Network-Intf   Out-Label
Lkps/St
1          vc1              1300         240        eth4            140
0/Up

#show mpls vpls mesh
VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX  SIG-Protocol
1          1.1.1.1          2100          110        eth2            210
0/Up       2         STATIC
1          2.2.2.2          2200          120        eth3            220
0/Up      1         STATIC

#show vpls vpls1 mac-address
MAC address      Learned from    Peer address
00 00 0B 00 05 00    eth2          1.1.1.1
```

PE-4

```
#show mpls-tp tunnel
<===============================================================================
=>
 Tunnel-id              : 4                 Tunnel-Name         : tn4
 Source Global-Id       : 300               Source Node-Id      : 3.3.3.3
 Destination Global-Id  : 400               Destination Node-Id : 4.4.4.4
 Role   : Destination                       Tunnel Index        : 1
 Mode   : COROUTED(bidirectional)           Tunnel State        : UP


     Forward-Path : ILM   <OPCODE : Pop>
       Incoming-Label : 1300                 Incoming-Interface  : eth4
       ILM-Index      : 1                    Cross-Connect-Index : 1
       Status : UP
     Reverse-Path : NHLFE   <OPCODE : Push>
       Outgoing-Label : 2300                 Outgoing-Interface : eth4
       NHLFE Index    : 1                    Nexthop MAC        : 0010.1874.0b4e
       BW-class       : N/A
       Status : UP
<===============================================================================
=>

#show mpls vpls detail
Virtual Private LAN Service Instance: vpls1, ID: 1
 SIG-Protocol: N/A
 Learning: Enabled
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 Operating mode: Raw
 Configured interfaces:
 none
 Spoke Peers: vc1 (Up)

#show mpls vpls spoke
VPLS-ID    Virtual Circuit  Tunnel-Label In-Label   Network-Intf   Out-Label
Lkps/St
1          vc1              2300         140        eth4            240
0/Up

#show vpls vpls1 mac-address
MAC address      Learned from    Peer address
00 00 0B 00 05 00    eth4         3.3.3.3
```

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