MPLS Layer 2 VPNs Configuration Guide, Cisco IOS XE 16 (Cisco ASR 920 Series)

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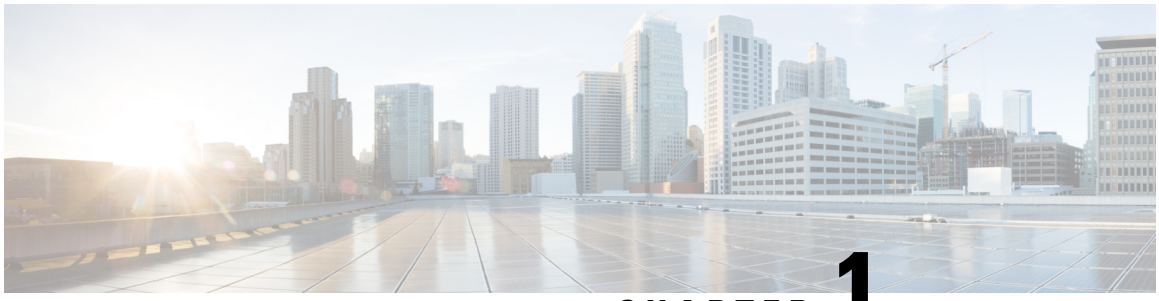
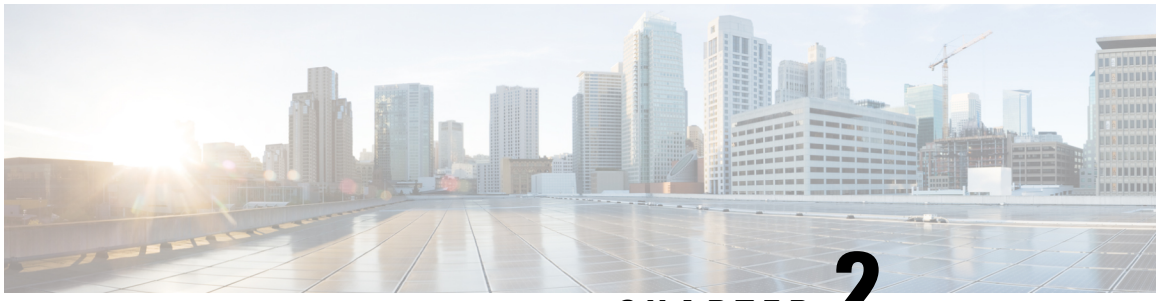


CHAPTER 1

Feature History

The following table lists the new and modified features supported in the MPLS Layer 2 VPNs Configuration Guide in Cisco IOS XE 16 releases.

Feature Name	Cisco IOS XE Release
VPLS over Backup Pseudowire	16.8.1b



CHAPTER 2

L2VPN Protocol-Based CLIs

The L2VPN Protocol-Based CLIs feature provides a set of processes and an improved infrastructure for developing and delivering Cisco IOS software on various Cisco platforms. This feature introduces new commands and modifies or replaces existing commands to achieve a consistent functionality across Cisco platforms and provide cross-Operating System (OS) support.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About L2VPN Protocol-Based CLIs

Overview of L2VPN Protocol-Based CLIs

The L2VPN Protocol-Based CLIs feature introduces new commands and modifies or replaces existing commands to achieve a consistent functionality across Cisco platforms and provide cross-Operating System (OS) support.

Note The new, updated, and replacement commands are available in Cisco IOS XE Release 3.7S and Cisco IOS Release 15.3(1)S. However, the legacy commands that are being replaced will be deprecated in later releases.

Benefits of L2VPN Protocol-Based CLIs

The L2VPN Protocol-Based CLIs feature provides the following benefits:

- Consistent user experience across different operating systems.
- Consistent configuration for all Layer 2 VPN (L2VPN) scenarios.
- Enhanced functionality that is achieved by configuring pseudowires as virtual interfaces and monitoring the pseudowires as physical ports.
- Feature configuration such as quality of service (QoS) service policies on individual pseudowires .
- Redundant pseudowire configuration that is independent of the primary pseudowire to provide enhanced high availability.

These benefits are achieved through the following enhancements:

- New service contexts can be created for point-to-point and multipoint Layer 2 services by using the new L2VPN cross connect and L2VPN virtual forwarding interface (VFI) contexts.
  - The L2VPN cross connect context is used for configuring point-to-point pseudowires, pseudowire stitching, and local switching (hair pinning). Ethernet interfaces , Ethernet Flow Points (EFP), ATM interfaces and WAN interfaces (PPP,HDLC,Serial), and pseudowire interfaces can be defined as members of an L2VPN cross connect context.
  - The L2VPN VFI context instantiates Virtual Private LAN Services (VPLS) VFI for multipoint scenarios. Pseudowires can be defined as members of an L2VPN VFI context.
  - Bridge domains are used for multipoint scenarios. EFPs, pseudowires, or VFIs can be configured as members of a bridge domain. Pseudowires can be configured as member of a VFI. The VFI can be configured as a member of a bridge domains.
- New port contexts can be created (dynamically or manually) for pseudowires by using the pseudowire interface.
- Pseudowire customization can be achieved using interface templates and pseudowire interfaces that are applied to L2VPN context members. Pseudowire customizations include following features:
  - Encapsulation type
  - Control word
  - Maximum Transmission Unit (MTU)
  - Pseudowire signaling type
  - Tunnel selection
- Interworking and redundancy group service attributes can be configured under the L2VPN service context. The redundancy groups are configured independently from the primary pseudowire, which helps achieve zero traffic interruptions while adding, modifying, or deleting backup pseudowires.

L2VPN Protocol-Based CLI Changes

The following commands are introduced in Cisco IOS XE Release 3.7S, Cisco IOS Release 15.3(1)S, and Cisco IOS Release 15.4(1)S:

- **debug l2vpn pseudowire**
- **l2vpn**
- **l2vpn pseudowire static-oam class**
- **monitor event-trace l2vpn**
- **show interface pseudowire**
- **show l2vpn service**
- **shutdown (MPLS)**
- **vc**

The following commands are modified in Cisco IOS XE Release 3.7S and Cisco IOS Release 15.3(1)S:

- **auto-route-target**
- **bridge-domain parameterized vlan**
- **debug condition xconnect fib**
- **debug condition xconnect interface**
- **debug condition xconnect peer**
- **debug condition xconnect segment**
- **description**
- **encapsulation (MPLS)**
- **forward permit l2protocol all**
- **interworking**
- **l2vpn subscriber authorization group**
- **l2vpn xconnect context**
- **load-balance flow**
- **monitor event-trace ac**
- **monitor event-trace atom**
- **monitor event-trace l2tp**
- **monitor peer bfd**
- **mtu**
- **preferred-path**
- **remote circuit id**

- **rd (VPLS)**
- **route-target (VPLS)**
- **sequencing**
- **status**
- **status admin-down disconnect**
- **status control-plane route-watch**
- **status decoupled**
- **status peer topology dual-homed**
- **status protocol notification static**
- **status redundancy**
- **switching tlv**
- **tlv**
- **tlv template**
- **vccv**
- **vccv bfd status signaling**
- **vccv bfd template**
- **vpls-id**
- **vpn id (MPLS)**

The table below lists the legacy commands that will be replaced in future releases. From Cisco IOS XE Release 3.7S and Cisco IOS Release 15.3(1)S both new and legacy commands will coexist until the legacy commands are deprecated in future releases.

Table 1: Replacement Commands Introduced in Cisco IOS XE Release 3.7S and Cisco IOS Release 15.3(1)S

Legacy Command	Replacement Command Introduced in Cisco IOS XE Release 3.7S and Cisco IOS Release 15.3(1)S
backup delay	**redundancy delay (under l2vpn xconnect context)**
bridge-domain (service instance)	**member (bridge-domain)**
clear mpls l2transport fsm state transition	**clear l2vpn atom fsm state transition**
clear mpls l2transport fsm event	**clear l2vpn atom fsm event**
clear xconnect	**clear l2vpn service**
connect (L2VPN local switching)	**l2vpn xconnect context**
debug acircuit	**debug l2vpn acircuit**

Legacy Command	Replacement Command Introduced in Cisco IOS XE Release 3.7S and Cisco IOS Release 15.3(1)S
debug mpls l2transport checkpoint	debug l2vpn atom checkpoint
debug mpls l2transport event-trace	debug l2vpn atom event-trace
debug mpls l2transport fast-failure-detect	debug l2vpn atom fast-failure-detect
debug mpls l2transport signaling	debug l2vpn atom signaling
debug mpls l2transport static-oam	debug l2vpn atom static-oam
debug mpls l2transport vc subscriber	debug l2vpn atom vc
debug mpls l2transport vc	debug l2vpn atom vc
debug mpls l2transport vc vccv bfd event	debug l2vpn atom vc vccv
debug vfi	debug l2vpn vfi
debug vfi checkpoint	debug l2vpn vfi checkpoint
debug xconnect	debug l2vpn xconnect
debug xconnect rib	debug l2vpn xconnect rib
description (L2VFI)	description (L2VPN)
l2 pseudowire routing	pseudowire routing
l2 router-id	router-id
l2 vfi	l2vpn vfi context
l2 subscriber	l2vpn subscriber
l2 vfi autodiscovery	autodiscovery
l2 vfi point-to-point	l2vpn xconnect context
local interface	pseudowire type
monitor event-trace st-pw-oam	monitor event-trace pwoam
mpls label	label (pseudowire)
mpls control-word	control-word (encapsulation mpls under l2vpn connect context)
neighbor (l2 vfi)	member (l2vpn vfi)
protocol	signaling protocol
pseudowire-static-oam class	l2vpn pseudowire static-oam class

Legacy Command	Replacement Command Introduced in Cisco IOS XE Release 3.7S and Cisco IOS Release 15.3(1)S
pseudowire tlv template	**l2vpn pseudowire tlv template**
pw-class keyword in the **xconnect** command	**source template type pseudowire**
remote link failure notification	**l2vpn remote link failure notification**
show mpls l2transport binding	**show l2vpn atom binding**
show mpls l2transport checkpoint	**show l2vpn atom checkpoint**
show mpls l2transport hw-capability	**show l2vpn atom hw-capability**
show mpls l2transport static-oam	**show l2vpn atom static-oam**
show mpls l2transport summary	**show l2vpn atom summary**
show mpls l2transport pwid	**show l2vpn atom pwid**
show mpls l2transport vc	**show l2vpn atom vc**
show xconnect pwmib	**show l2vpn pwmib**
show xconnect rib	**show l2vpn rib**
show xconnect	**show l2vpn service**
show vfi	**show l2vpn vfi**
xconnect	**l2vpn xconnect context** and **member**
xconnect logging pseudowire status global	**logging pseudowire status**
xconnect logging redundancy global	**logging redundancy**
xconnect *peer-ip vc-id*	**neighbor peer-ip vc-id (xconnect context)**

MPLS L2VPN Protocol-Based CLI: Examples

The examples in this section provide the new configurations that are introduced by the MPLS L2VPN Protocol-Based CLIs feature that replace the existing (legacy) MPLS L2VPN CLIs.

MPLS L2VPN VPWS Configuration Using Replacement (or New) Commands

The following example shows the configuration for Virtual Private Wired Service (VPWS)—Ethernet over Multiprotocol Label Switching (EoMPLS). In this example, L2VPN members point to peer ID or virtual circuit (VC) ID. This configuration is used in most cases except when features like quality of service (QoS), need to be applied at the pseudowire level.

```
l2vpn xconnect context foo
  member GigabitEthernet2/1/1 service-instance 300
  member 10.0.0.1 888 encapsulation mpls
!
interface GigabitEthernet2/1/1
```

```
  service instance 300 Ethernet
   encapsulation dot1q 30
   rewrite ingress tag pop 1 symmetric
  !
  service instance 400 Ethernet
   encapsulation dot1q 40
   rewrite ingress tag pop 1 symmetric

l2vpn xconnect context faa
  member GigabitEthernet2/1/1 service-instance 400
  member 10.0.0.1 999 encapsulation mpls
!
```

MPLS L2VPN Pseudowire Configuration Using Replacement (or New) Commands

In the following example, L2VPN members point to a pseudowire interface. The pseudowire interface is manually configured and includes peer ID and VC ID. This configuration is used in most cases except when features like quality of service (QoS), need to be applied at the pseudowire level.

```
l2vpn xconnect context foo
  member GigabitEthernet2/1/1 service-instance 300
  member Pseudowire888
!
interface Pseudowire 888
 encapsulation mpls
 neighbor 10.0.0.1 888
!
interface Pseudowire 999
 encapsulation mpls
 neighbor 10.0.0.1 999
!
interface GigabitEthernet2/1/1
  service instance 300 Ethernet
   encapsulation dot1q 30
   rewrite ingress tag pop 1 symmetric
  !
  service instance 400 Ethernet
   encapsulation dot1q 40
   rewrite ingress tag pop 1 symmetric

l2vpn xconnect context faa
  member GigabitEthernet2/1/1 service-instance 400
  member Pseudowire 999
!
```

MPLS L2VPN Pseudowire Redundancy Configuration Using Replacement (or New) Commands

The following example shows the configuration for pseudowire redundancy. The new configuration shows concise pseudowire redundancy with no submodes or separate groups. This configuration allows the addition of redundant members to a service without service disruption. This configuration also allows modifying or deleting redundant service configurations without service disruption.

```
l2vpn xconnect context sample-pw-redundancy
  member GigabitEthernet2/1/1 service-instance 200
  member 1.1.1.1 180 encap mpls group Denver
  member 2.2.2.2 180180 encap mpls group Denver priority 1
  member 3.3.3.3 180181 encap mpls group Denver priority 2
  redundancy delay 1 20 group Denver
!
interface GigabitEthernet2/1/1
  service instance 200 Ethernet
   encapsulation dot1q 100
   rewrite ingress tag pop 1 symmetric
```

MPLS L2VPN Static Pseudowire Configuration Using Replacement (or New) Commands

Note The following configuration is shown for the Provider Edge (PE) 1 router in a network scheme where Customer Edge (CE) 1 and PE 1 and PE 2 and CE 2 traverse through a Provider core (P) router (CE 1—PE 1—P—PE 2—CE 2).

```
interface g2/1/1
service instance 300 ethernet
encapsulation dot1q 300
no shutdown
!
interface pseudowire 100
neighbor 10.4.4.4 121
encapsulation mpls
label 200 300
signaling protocol none
no shutdown
!
l2vpn xconnect context foo
  member GigabitEthernet2/1/1 service-instance 300
  member pseudowire 100
```

MPLS L2VPN Static Pseudowire Template Configuration Using Replacement (or New) Commands

Note The following configuration is shown for the Provider Edge (PE) 1 router in a network scheme where Customer Edge (CE) 1 and PE 1 and PE 2 and CE 2 traverse through a Provider core (P) router (CE 1—PE 1—P—PE 2—CE 2).

```
template type pseudowire test
encapsulation mpls
signaling protocol none
!
interface g2/1/1
service instance 300 ethernet
encapsulation dot1q 300
no shutdown
!
interface pseudowire 100
neighbor 10.4.4.4 121
source template type pseudowire test
label 200 300
no shutdown
!
l2vpn xconnect context foo
  member GigabitEthernet2/1/1 service-instance 300
  member pseudowire 100
```

MPLS L2VPN Dynamic Pseudowire Template Configuration Using Replacement (or New) Commands

Note The following configuration is shown for the Provider Edge (PE) 1 router in a network scheme where Customer Edge (CE) 1 and PE 1 and PE 2 and CE 2 traverse through a Provider core (P) router (CE 1—PE 1—P—PE 2—CE 2).

```
template type pseudowire test
encapsulation mpls
signaling protocol ldp
!
!
interface g2/1/1
service instance 300 ethernet
encapsulation dot1q 300
no shutdown
!
interface pseudowire 100
neighbor 10.4.4.4 121
source template type pseudowire test
no shutdown
!
l2vpn xconnect context foo
  member GigabitEthernet2/1/1 service-instance 300
  member pseudowire 100
```

MPLS L2VPN Multi-segment Static-Dynamic Pseudowire Template Configuration Using Replacement (or New) Commands

The following PE router configuration is for a multi-segment static-dynamic pseudowire:

```
l2vpn pseudowire tlv template TLV
 tlv mtu 1 4 dec 1500
!
interface pseudowire401
  source template type pseudowire staticTempl
encapsulation mpls
neighbor 10.4.4.4 101
signaling protocol none
label 4401 4301
pseudowire type 4
tlv template TLV
tlv 1 4 dec 1500
tlv vccv-flags C 4 hexstr 0110
!
interface pseudowire501
  source template type pseudowire dynTempl
encapsulation mpls
neighbor 10.2.2.2 101
signaling protocol ldp
```

Displaying MPLS L2VPN Pseudowire Template Configuration Using Replacement (or New) Commands

The following example displays output from the **show interface pseudowire** command:

```
PE1#show interface pseudowire 100
pseudowire100 is up
    Description: Pseudowire Interface
    MTU 1500 bytes, BW 10000000 Kbit
    Encapsulation mpls
    Peer IP 10.4.4.4, VC ID 121
    RX
      21 packets 2623 bytes 0 drops
    TX
      20 packets 2746 bytes 0 drops
```

The following example displays output from the **show template** command:

```
PE1#show template

Template        class/type    Component(s)
ABC             owner        interface pseudowire
 BOUND: pw1
```

Sourcing a Template Under an Interface Pseudowire Using Replacement (or New) Commands

The following example configures the interface pseudowire to inherit all attributes defined from a template on the PE 2 router.

```
PE2(config-subif)#interface pseudowire 100
PE2(config-if)#source template type pseudowire test
PE2(config-if)#neighbor 10.4.4.4 121
PE2(config-if)#no shutdown
```

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
MPLS commands	Multiprotocol Label Switching Command Reference

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

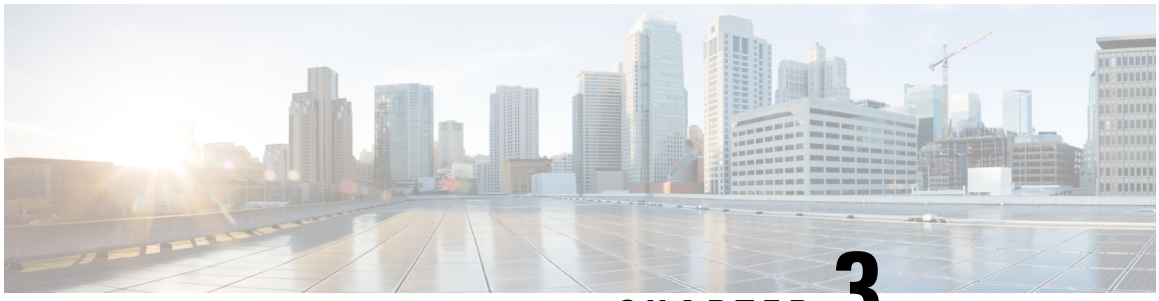
Feature Information for L2VPN Protocol-Based CLI

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 2: Feature Information for L2VPN Protocol-Based CLI

Feature Name	Releases	Feature Information
L2VPN Protocol-Based CLIs	Cisco IOS XE Release 3.13.0S	This feature was introduced on the Cisco ASR 920 Routers (ASR-920-12CZ-A, ASR-920-12CZ-D, ASR-920-4SZ-A, ASR-920-4SZ-D).



CHAPTER 3

Any Transport over MPLS

This module describes how to configure Any Transport over MPLS (AToM) transports data link layer (Layer 2) packets over a Multiprotocol Label Switching (MPLS) backbone. AToM enables service providers to connect customer sites with existing Layer 2 networks by using a single, integrated, packet-based network infrastructure--a Cisco MPLS network. Instead of using separate networks with network management environments, service providers can deliver Layer 2 connections over an MPLS backbone. AToM provides a common framework to encapsulate and transport supported Layer 2 traffic types over an MPLS network core.

AToM supports the following like-to-like transport types:

- ATM Adaptation Layer Type-5 (AAL5) over MPLS
- ATM Cell Relay over MPLS
- Ethernet over MPLS (port modes)
- Circuit Emulation (CEM)

Note For information on ATM Cell relay and Circuit Emulation(CEM), see Configuring Pseudowire.

Finding Feature Information

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Prerequisites for Any Transport over MPLS

- IP routing must be configured in the core so that the provider edge (PE) routers can reach each other via IP.
- MPLS must be configured in the core so that a label-switched path (LSP) exists between the PE routers.
- A loopback interface must be configured for originating and terminating Layer 2 traffic. Ensure that the PE routers can access the other router's loopback interface. Note that the loopback interface is not needed in all cases. For example, tunnel selection does not need a loopback interface when AToM is directly mapped to a traffic engineering (TE) tunnel.

General Restrictions

- Address format--Configure the Label Distribution Protocol (LDP) router ID on all PE routers to be a loopback address with a /32 mask. Otherwise, some configurations might not function properly.
- For PTPoIP configuration with explicit Null MPLS encapsulation, when a Transparent Clock (TC) is placed between a PTP master and a PTP slave, the TC does not update the correction field.
- TE-FRR with BGP labels for layer 2 and layer 3 VPNs must terminate on the BGP gateway because of the four-label limitation.
- If an AToM tunnel spans different service providers that exchange MPLS labels using IPv4 Border Gateway Protocol (BGP) (RFC 3107), you add a label to the stack. The maximum MPLS label stack is four (FRR label, TE label, LDP label, VC label).
- Hot standby pseudowire (HSPW) convergence without pseudowire grouping increments linearly. For example, for a thousand virtual circuits, it requires about 54 seconds of convergence time. This is applicable only for the Cisco RSP3 Module.

  Clear interface is not the recommended way to measure the convergence numbers.
- With two ECMP paths, load sharing on L2VPN traffic occurs based on odd or even MPLS VC labels. If L2VPN circuits have either odd **or** even MPLS VC labels, load sharing is not performed. But if L2VPN circuits have a combination of both odd **and** even MPLS VC labels, then the odd MPLS VC labels circuits will select one link whereas the even MPLS VC labels circuits will select another link.
- Flow-Aware Transport (FAT) Load Balancing over VPLS is not supported.

ATM AAL5 over MPLS Restrictions

- AAL5 over MPLS is supported only in SDU mode.

Ethernet over MPLS (EoMPLS) Restrictions

- The subinterfaces between the CE and PE routers that are running Ethernet over MPLS must be in the same subnet.
- The subinterface on the adjoining CE router must be on the same VLAN as the PE router.
- Ethernet over MPLS supports VLAN packets that conform to the IEEE 802.1Q standard. The 802.1Q specification establishes a standard method for inserting VLAN membership information into Ethernet frames. The Inter-Switch Link (ISL) protocol is not supported between the PE and CE routers.
- The AToM control word is supported. However, if the peer PE does not support a control word, the control word is disabled.
- Ethernet packets with hardware-level cyclic redundancy check (CRC) errors, framing errors, and runt packets are discarded on input.

Tunnel Selection Restrictions

- The selected path should be an LSP destined to the peer PE router.
- The selected tunnel must be an MPLS TE tunnel.
- If you specify an IP address, that address must be the IP address of the loopback interface on the remote PE router. The address must have a /32 mask. There must be an LSP destined to that selected address. The LSP need not be a TE tunnel.

Remote Ethernet Port Shutdown Restrictions

This feature is not symmetrical if the remote PE router is running an older version image or is on another platform that does not support the EoMPLS remote Ethernet port shutdown feature and the local PE is running an image which supports this feature.

Remote Ethernet Port Shutdown is supported only on EFP with encapsulation default.

Restrictions for PPP and Multilink PPP

- All member links in a Multilink PPP bundle must be on the same interface module.
- All member links in a Multilink PPP bundle must be of the same bandwidth.
- A maximum of 16 member links per bundle is supported.

- Perform a shutdown or no shutdown of the Multilink PPP bundle to change the bundle fragmentation mode between enabled and disabled.
- Link Fragmentation and Interleaving (LFI) is not supported. However, Multilink PPP fragmentation is supported by default. To disable fragmentation, see *Disabling PPP Multilink Fragmentation* section.
- Multicast Multilink PPP is not supported.
- PPP compression is not supported.
- IPv6 is not supported for this feature.
- PPP half bridging is not supported.
- To enable an Address-and-Control-Field-Compression (ACFC) or Protocol-Field-Compression (PFC) configuration, perform a shutdown or no shutdown on the serial interface.
- Fractional timeslots cannot be used as memberlink in a Multilink PPP bundle.
- Frame Relay (FR) and Multilink Frame Relay (MFR) are not supported.
- Compressing IP or UDP or RTP headers are not supported.
- PPP and Multilink PPP are supported on synchronous serial interfaces. Asynchronous serial interfaces, High-Speed Serial Interfaces (HSSI), and ISDN interfaces are not supported.
- When you configure interfaces on each end of an Multilink PPP connection with different MTU values, the link drops traffic at high traffic rates. The configuration of the same MTU is recommended.

Information About Any Transport over MPLS

To configure AToM, you must understand the following concepts:

How AToM Transports Layer 2 Packets

AToM encapsulates Layer 2 frames at the ingress PE and sends them to a corresponding PE at the other end of a pseudowire, which is a connection between the two PE routers. The egress PE removes the encapsulation and sends out the Layer 2 frame.

The successful transmission of the Layer 2 frames between PE routers is due to the configuration of the PE routers. You set up the connection, called a pseudowire, between the routers. You specify the following information on each PE router:

- The type of Layer 2 data that will be transported across the pseudowire, such as Ethernet, Frame Relay, or ATM
- The IP address of the loopback interface of the peer PE router, which enables the PE routers to communicate
- A unique combination of peer PE IP address and VC ID that identifies the pseudowire

The following example shows the basic configuration steps on a PE router that enable the transport of Layer 2 packets. Each transport type has slightly different steps.

Step 1 defines the interface or subinterface on the PE router:

```
Router# interface
 interface-type interface-number
```

Step 2 configures an ethernet service instance on an interface and enters service instance configuration mode:

```
Router(config-if)#service instance number ethernet WORD
Router(config-if)# service instance 393 ethernet ethernet1
```

Step 3 specifies the encapsulation type for the interface, such as dot1q:

```
Router(config-if-srv)# encapsulation
encapsulation-type
```

Step 4 does the following:

- Makes a connection to the peer PE router by specifying the LDP router ID of the peer PE router.
- Specifies a 32-bit unique identifier, called the VC ID, which is shared between the two PE routers.

The combination of the peer router ID and the VC ID must be unique on the router. Two circuits cannot use the same combination of peer router ID and VC ID.

- Specifies the tunneling method used to encapsulate data in the pseudowire. AToM uses MPLS as the tunneling method.

```
Router(config-if-srv)# xconnect
peer-router-id vcid
encapsulation mpls
```

As an alternative, you can set up a pseudowire class to specify the tunneling method and other characteristics. For more information, see the Configuring the Pseudowire Class, on page 27.

How AToM Transports Layer 2 Packets Using Commands Associated with L2VPN Protocol-Based Feature

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Step 1 defines the interface or subinterface on the PE router:

```
Router# interface
interface-type interface-number

Router(config)# interface gi 0/1/0
```

Step 2 configures an ethernet service instance on an interface and enters service instance configuration mode:

```
Router(config-if)#service instance number ethernet WORD
Router(config-if)# service instance 393 ethernet ethernet1
```

Step 3 specifies the encapsulation type for the interface, such as dot1q:

```
Router(config-if)# encapsulation
encapsulation-type

Router(config-if-srv)# encapsulation dot1q 393
```

Step 3 does the following:

- Makes a connection to the peer PE router by specifying the LDP router ID of the peer PE router.
- Specifies a 32-bit unique identifier, called the VC ID, which is shared between the two PE routers.

The combination of the peer router ID and the VC ID must be unique on the router. Two circuits cannot use the same combination of peer router ID and VC ID.

- Specifies the tunneling method used to encapsulate data in the pseudowire. AToM uses MPLS as the tunneling method.

```
Router(config)# interface pseudowire 100
Router(config-if)# encapsulation mpls
Router(config-if)# neighbor 10.0.0.1 123
Router(config-if)# exit
!
Router(config)# l2vpn xconnect context A
Router(config-xconnect)# member pseudowire 100

Router (config-xconnect)# member gigabitethernet0/1/0 service instance 393

Router(config-xconnect)# exit
```

As an alternative, you can set up a pseudowire class to specify the tunneling method and other characteristics. For more information, see the Configuring the Pseudowire Class, on page 27.

Benefits of AToM

The following list explains some of the benefits of enabling Layer 2 packets to be sent in the MPLS network:

- The AToM product set accommodates many types of Layer 2 packets, including Ethernet and Frame Relay, across multiple Cisco router platforms. This enables the service provider to transport all types of traffic over the backbone and accommodate all types of customers.
- AToM adheres to the standards developed for transporting Layer 2 packets over MPLS. This benefits the service provider that wants to incorporate industry-standard methodologies in the network. Other Layer 2 solutions are proprietary, which can limit the service provider's ability to expand the network and can force the service provider to use only one vendor's equipment.

- Upgrading to AToM is transparent to the customer. Because the service provider network is separate from the customer network, the service provider can upgrade to AToM without disruption of service to the customer. The customers assume that they are using a traditional Layer 2 backbone.

MPLS Traffic Engineering Fast Reroute

AToM can use MPLS traffic engineering (TE) tunnels with fast reroute (FRR) support. AToM VCs can be rerouted around a failed link or node at the same time as MPLS and IP prefixes.

Enabling fast reroute on AToM does not require any special commands; you can use standard fast reroute commands. At the ingress PE, an AToM tunnel is protected by fast reroute when it is routed to an FRR-protected TE tunnel. Both link and node protection are supported for AToM VCs at the ingress PE.

Maximum Transmission Unit Guidelines for Estimating Packet Size

The following calculation helps you determine the size of the packets traveling through the core network. You set the maximum transmission unit (MTU) on the core-facing interfaces of the P and PE routers to accommodate packets of this size. The MTU should be greater than or equal to the total bytes of the items in the following equation:

```
Core MTU >= (Edge MTU + Transport header + AToM header + (MPLS label stack * MPLS label
size))
```

The following sections describe the variables used in the equation.

Edge MTU

The edge MTU is the MTU for the customer-facing interfaces.

Transport Header

The Transport header depends on the transport type. The table below lists the specific sizes of the headers.

Table 3: Header Size of Packets

Transport Type	Packet Size
AAL5	0-32 bytes
Ethernet VLAN	18 bytes
Ethernet Port	14 bytes
Frame Relay DLCI	2 bytes for Cisco encapsulation, 8 bytes for Internet Engineering Task Force (IETF) encapsulation
HDLC	4 bytes
PPP	4 bytes

AToM Header

The AToM header is 4 bytes (control word). The control word is optional for Ethernet, PPP, HDLC, and cell relay transport types. The control word is required for Frame Relay and ATM AAL5 transport types.

MPLS Label Stack

The MPLS label stack size depends on the configuration of the core MPLS network:

- AToM uses one MPLS label to identify the AToM VCs (VC label). Therefore, the minimum MPLS label stack is one for directly connected AToM PEs, which are PE routers that do not have a P router between them.
- If LDP is used in the MPLS network, the label stack size is two (the LDP label and the VC label).
- If a TE tunnel instead of LDP is used between PE routers in the MPLS network, the label stack size is two (the TE label and the VC label).
- If a TE tunnel and LDP are used in the MPLS network (for example, a TE tunnel between P routers or between P and PE routers, with LDP on the tunnel), the label stack is three (TE label, LDP label, VC label).
- If you use MPLS fast reroute in the MPLS network, you add a label to the stack. The maximum MPLS label stack in this case is four (FRR label, TE label, LDP label, VC label).
- If AToM is used by the customer carrier in an MPLS VPN Carrier Supporting Carrier environment, you add a label to the stack. The maximum MPLS label stack in the provider carrier network is four (FRR label, TE label, LDP label, VC label).
- If an AToM tunnel spans different service providers that exchange MPLS labels using IPv4 Border Gateway Protocol (BGP) (RFC 3107), you add a label to the stack. The maximum MPLS label stack is four (FRR label, TE label, LDP label, VC label)
- TE-FRR with BGP labels for layer 2 and layer 3 VPNs must terminate on the BGP gateway because of the four-label limitation.

Other circumstances can increase the MPLS label stack size. Therefore, analyze the complete data path between the AToM tunnel endpoints and determine the maximum MPLS label stack size for your network. Then multiply the label stack size by the size of the MPLS label.

Estimating Packet Size Example

The estimated packet size in the following example is 1526 bytes, based on the following assumptions:

- The edge MTU is 1500 bytes.
- The transport type is Ethernet VLAN, which designates 18 bytes for the transport header.
- The AToM header is 0, because the control word is not used.
- The MPLS label stack is 2, because LDP is used. The MPLS label is 4 bytes.

```
Edge MTU + Transport header + AToM header + (MPLS label stack * MPLS label) = Core MTU
1500     + 18                + 0          + (2                * 4          ) = 1526
```

You must configure the P and PE routers in the core to accept packets of 1526 bytes.

QoS Features Supported with AToM

The tables below list the QoS features supported by AToM.

Table 4: QoS Features Supported with Ethernet over MPLS

QoS Feature	Ethernet over MPLS
Service policy	Can be applied to: • Interface (input and output)
Classification	Supports the following commands: • **match cos** (on interfaces) • **match mpls experimental** (on interfaces) • **match qos-group** (on interfaces) (output policy)
Marking	Supports the following commands: • **set cos** (output policy) • **set discard-class** (input policy) • **set mpls experimental** (input policy) (on interfaces) • **set qos-group** (input policy)
Policing	Supports the following: • Color-aware policing • Multiple-action policing • Single-rate policing • Two-rate policing
Queueing and shaping	Supports the following: • Byte-based WRED • Low Latency Queueing (LLQ) • Weighted Random Early Detection (WRED)

Table 5: QoS Features Supported with Frame Relay over MPLS

QoS Feature	Frame Relay over MPLS
Service policy	Can be applied to: • Interface (input and output) • PVC (input and output)
Classification	Supports the following commands: • **match fr-de** (on interfaces and VCs) • **match fr-dlci** (on interfaces) • **match qos-group**
Marking	Supports the following commands: • **frame-relay congestion management** (output) • **set discard-class** • **set fr-de** (output policy) • **set fr-fecn-becn** (output) • **set mpls experimental** • **set qos-group** • **threshold ecn** (output)
Policing	Supports the following: • Color-aware policing • Multiple-action policing • Single-rate policing • Two-rate policing

QoS Feature	Frame Relay over MPLS
Queueing and shaping	Supports the following: • Byte-based WRED • Class-based weighted fair queueing (CBWFQ) • LLQ • **random-detect discard-class-based** command • Traffic shaping • WRED

Table 6: QoS Features Supported with ATM Cell Relay and AAL5 over MPLS

QoS Feature	ATM Cell Relay and AAL5 over MPLS
Service policy	Can be applied to: • Interface (input and output) • PVC (input and output) • Subinterface (input and output)
Classification	Supports the following commands: • **match mpls experimental** (on VCs) • **match qos-group** (output)
Marking	Supports the following commands: • **random-detect discard-class-based** (input) • **set clp** (output) (on interfaces, subinterfaces, and VCs) • **set discard-class** (input) • **set mpls experimental** (input) (on interfaces, subinterfaces, and VCs) • **set qos-group** (input)
Policing	Supports the following: • Color-aware policing • Multiple-action policing • Single-rate policing • Two-rate policing

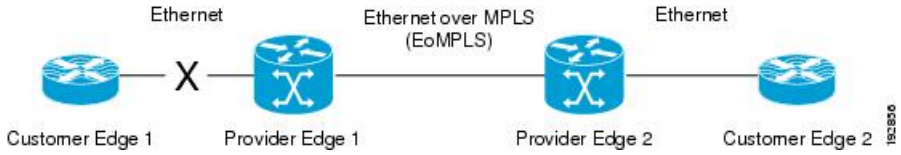
QoS Feature	ATM Cell Relay and AAL5 over MPLS
Queueing and shaping	Supports the following: • Byte-based WRED • CBWFQ • Class-based shaping support on ATM PVCs • LLQ • **random-detect discard-class-based** command • WRED

Any Transport over MPLS (AToM) Remote Ethernet Port Shutdown

This Cisco IOS XE feature allows a service provider edge (PE) router on the local end of an Ethernet over MPLS (EoMPLS) pseudowire to detect a remote link failure and cause the shutdown of the Ethernet port on the local customer edge (CE) router. Because the Ethernet port on the local CE router is shut down, the router does not lose data by continuously sending traffic to the failed remote link. This is beneficial if the link is configured as a static IP route.

The figure below illustrates a condition in an EoMPLS WAN, with a down Layer 2 tunnel link between a CE router (Customer Edge 1) and the PE router (Provider Edge 1). A CE router on the far side of the Layer 2 tunnel (Customer Edge 2), continues to forward traffic to Customer Edge 1 through the L2 tunnel.

Figure 1: Remote Link Outage in EoMPLS WAN



Previous to this feature, the Provider Edge 2 router could not detect a failed remote link. Traffic forwarded from Customer Edge 2 to Customer Edge 1 would be lost until routing or spanning tree protocols detected the down remote link. If the link was configured with static routing, the remote link outage would be even more difficult to detect.

With this feature, the Provider Edge 2 router detects the remote link failure and causes a shutdown of the local Customer Edge 2 Ethernet port. When the remote L2 tunnel link is restored, the local interface is automatically restored as well. The possibility of data loss is thus diminished.

With reference to the figure above, the Remote Ethernet Shutdown sequence is generally described as follows:

1. The remote link between Customer Edge 1 and Provider Edge 1 fails.
2. Provider Edge 2 detects the remote link failure and disables the transmit laser on the line card interface connected to Customer Edge 2.
3. An RX_LOS error alarm is received by Customer Edge 2 causing Customer Edge 2 to bring down the interface.
4. Provider Edge 2 maintains its interface with Customer Edge 2 in an up state.

5. When the remote link and EoMPLS connection is restored, the Provider Edge 2 router enables the transmit laser.
6. The Customer Edge 2 router brings up its downed interface.

This feature is enabled by default for Ethernet over MPLS (EoMPLS). You can also enable this feature by using the **remote link failure notification** command in xconnect configuration mode as shown in the following example:

```
pseudowire-class eompls
 encapsulation mpls
!
interface GigabitEthernet1/0/0
 xconnect 10.13.13.13 1 pw-class eompls
  remote link failure notification
!
```

This feature can be disabled using the **no remote link failure notification** command in xconnect configuration mode. Use the **show ip interface brief** privileged EXEC command to display the status of all remote L2 tunnel links. Use the **show interface** privileged EXEC command to show the status of the L2 tunnel on a specific interface.

Note The **no remote link failure notification** command will not give notification to clients for remote attachment circuit status down.

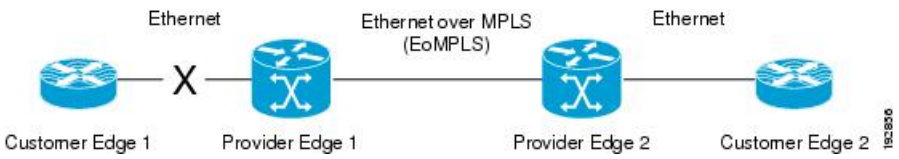
Note Remote Ethernet Port Shutdown is supported only on EFP with encapsulation default.

Any Transport over MPLS (AToM) Remote Ethernet Port Shutdown Using Commands Associated with L2VPN Protocol-Based Feature

This Cisco IOS XE feature allows a service provider edge (PE) router on the local end of an Ethernet over MPLS (EoMPLS) pseudowire to detect a remote link failure and cause the shutdown of the Ethernet port on the local customer edge (CE) router. Because the Ethernet port on the local CE router is shut down, the router does not lose data by continuously sending traffic to the failed remote link. This is beneficial if the link is configured as a static IP route.

The figure below illustrates a condition in an EoMPLS WAN, with a down Layer 2 tunnel link between a CE router (Customer Edge 1) and the PE router (Provider Edge 1). A CE router on the far side of the Layer 2 tunnel (Customer Edge 2), continues to forward traffic to Customer Edge 1 through the L2 tunnel.

Figure 2: Remote Link Outage in EoMPLS WAN



Previous to this feature, the Provider Edge 2 router could not detect a failed remote link. Traffic forwarded from Customer Edge 2 to Customer Edge 1 would be lost until routing or spanning tree protocols detected the down remote link. If the link was configured with static routing, the remote link outage would be even more difficult to detect.

With this feature, the Provider Edge 2 router detects the remote link failure and causes a shutdown of the local Customer Edge 2 Ethernet port. When the remote L2 tunnel link is restored, the local interface is automatically restored as well. The possibility of data loss is thus diminished.

With reference to the figure above, the Remote Ethernet Shutdown sequence is generally described as follows:

1. The remote link between Customer Edge 1 and Provider Edge 1 fails.
2. Provider Edge 2 detects the remote link failure and disables the transmit laser on the line card interface connected to Customer Edge 2.
3. An RX_LOS error alarm is received by Customer Edge 2 causing Customer Edge 2 to bring down the interface.
4. Provider Edge 2 maintains its interface with Customer Edge 2 in an up state.
5. When the remote link and EoMPLS connection is restored, the Provider Edge 2 router enables the transmit laser.
6. The Customer Edge 2 router brings up its downed interface.

This feature is enabled by default for Ethernet over MPLS (EoMPLS). You can also enable this feature by using the **remote link failure notification** command in xconnect configuration mode as shown in the following example:

```
l2vpn xconnect context con1
member GigabitEthernet1/0/0 service-instance 300
member Pseudowire 100
remote link failure notification
```

This feature can be disabled using the **no remote link failure notification** command in xconnect configuration mode. Use the **show ip interface brief** privileged EXEC command to display the status of all remote L2 tunnel links. Use the **show interface** privileged EXEC command to show the status of the L2 tunnel on a specific interface.

Note The **no remote link failure notification** command will not give notification to clients for remote attachment circuit status down.

How to Configure Any Transport over MPLS

This section explains how to perform a basic AToM configuration and includes the following procedures:

Configuring the Pseudowire Class

Note In simple configurations, this task is optional. You need not specify a pseudowire class if you specify the tunneling method as part of the **xconnect** command.

- You must specify the **encapsulation mpls** command as part of the pseudowire class or as part of the **xconnect** command for the AToM VCs to work properly. If you omit the **encapsulation mpls** command as part of the **xconnect** command, you receive the following error:

```
% Incomplete command.
```

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **pseudowire-class** *name*
4. **encapsulation mpls**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**pseudowire-class** *name* **Example:** `Router(config)# pseudowire-class atom`	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
Step 4	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation.

Configuring the Pseudowire Class Using Commands Associated with L2VPN Protocol-Based Feature

Note In simple configurations, this task is optional. You need not specify a pseudowire class if you specify the tunneling method as part of the **l2vpn xconnect context** command.

- You must specify the **encapsulation mpls** command as part of the pseudowire class or as part of the **l2vpn xconnect context** command for the AToM VCs to work properly. If you omit the **encapsulation mpls** command as part of the **l2vpn xconnect context**command, you receive the following error:

```
% Incomplete command.
```

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface pseudowire** *name*
4. **encapsulation mpls**
5. **neighbor** *peer-address vcid-value*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface pseudowire** *name* **Example:** `Router(config)# interface pseudowire atom`	Establishes an interface pseudowire with a name that you specify and enters pseudowire class configuration mode.
Step 4	**encapsulation mpls** **Example:** `Router(config-pw-class)# encapsulation mpls`	Specifies the tunneling encapsulation.
Step 5	**neighbor** *peer-address vcid-value* **Example:**	Specifies the peer IP address and virtual circuit (VC) ID value of a Layer 2 VPN (L2VPN) pseudowire.

	Command or Action	Purpose
	`Router(config-pw-class)#  neighbor 33.33.33.33 1`	

Changing the Encapsulation Type and Removing a Pseudowire

Once you specify the **encapsulation mpls** command, you cannot remove it using the **no encapsulation mpls** command.

Those methods result in the following error message:

```
Encapsulation changes are not allowed on an existing pw-class.
```

To remove the **encapsulation mpls** command, you must delete the pseudowire with the **no pseudowire-class** command.

To change the type of encapsulation, remove the pseudowire using the **no pseudowire-class** command and reconfigure the pseudowire to specify the new encapsulation type.

Changing the Encapsulation Type and Removing a Pseudowire Using Commands Associated with the L2VPN Protocol-Based Feature

Once you specify the **encapsulation mpls** command, you cannot remove it using the **no encapsulation mpls** command.

Those methods result in the following error message:

```
% Cannot remove encapsulation on existing pseudowire
```

To remove the **encapsulation mpls** command, you must delete the pseudowire with the **no interface pseudowire** command.

To change the type of encapsulation, remove the pseudowire using the **no template type pseudowire** command and reconfigure the pseudowire to specify the new encapsulation type.

Configuring ATM AAL5 over MPLS

Configuring ATM AAL5 over MPLS on PVCs

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type slot / subslot / port* [**.** *subinterface*]
4. **pvc** [*name*] *vpi / vci* **l2transport**
5. **encapsulation aal5**
6. **xconnect** *peer-router-id vcid* **encapsulation mpls**
7. **end**
8. **show mpls l2transport vc**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type slot / subslot / port* [**.** *subinterface*] **Example:** `Router(config)# interface atm1/0/0`	Specifies the interface type and enters interface configuration mode.
Step 4	**pvc** [*name*] *vpi / vci* **l2transport** **Example:** `Router(config-if)# pvc 1/200 l2transport`	Creates or assigns a name to an ATM PVC and enters L2transport PVC configuration mode. • The **l2transport** keyword indicates that the PVC is a switched PVC instead of a terminated PVC.
Step 5	**encapsulation aal5** **Example:** `Router(config-if-atm-l2trans-pvc)# encapsulation aal5`	Specifies ATM AAL5 encapsulation for the PVC. Make sure you specify the same encapsulation type on the PE and customer edge (CE) routers.
Step 6	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(config-if-atm-l2trans-pvc)# xconnect 10.13.13.13 100 encapsulation mpls`	Binds the attachment circuit to a pseudowire VC.
Step 7	**end** **Example:** `Router(config-if-atm-l2trans-pvc)# end`	Exits to privileged EXEC mode.
Step 8	**show mpls l2transport vc** **Example:** `Router# show mpls l2transport vc`	Displays output that shows ATM AAL5 over MPLS is configured on a PVC.

Examples

The following is sample output from the **show mpls l2transport vc** command that shows that ATM AAL5 over MPLS is configured on a PVC:

```
Router# show mpls l2transport vc
Local intf   Local circuit          Dest address      VC ID      Status
---------    -------------          ------------      -----      ------
ATM1/0       ATM AAL5 1/100         10.4.4.4           100        UP
```

Configuring ATM AAL5 over MPLS on PVCs using the commands associated with the L2VPN Protocol-Based CLIs feature

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type slot* / *subslot* / *port*[**.** *subinterface*]
4. **pvc** [*name*] *vpi* / *vci* **l2transport**
5. **encapsulation aal5**
6. **end**
7. **interface pseudowire** *number*
8. **encapsulation mpls**
9. **neighbor** *peer-address vcid-value*
10. **exit**
11. **l2vpn xconnect context** *context-name*
12. **member pseudowire** *interface-number*
13. **member atm** *interface-number* **pvc** *vpi* / *vci*
14. **end**
15. **show l2vpn atom vc**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type slot* / *subslot* / *port*[**.** *subinterface*] **Example:**	Specifies the interface type and enters interface configuration mode.

	Command or Action	Purpose
	`Device(config)# interface atm1/0/0`	
Step 4	**pvc** [*name*] *vpi* / *vci* **l2transport** **Example:** `Device(config-if)# pvc 1/200 l2transport`	Creates or assigns a name to an ATM PVC and enters L2transport PVC configuration mode. • The **l2transport** keyword indicates that the PVC is a switched PVC instead of a terminated PVC.
Step 5	**encapsulation aal5** **Example:** `Device(config-if-atm-l2trans-pvc)# encapsulation aal5`	Specifies ATM AAL5 encapsulation for the PVC. Make sure you specify the same encapsulation type on the PE and customer edge (CE) routers.
Step 6	**end** **Example:** `Device(config-if-atm-l2trans-pvc)# end`	Exits to privileged EXEC mode.
Step 7	**interface pseudowire** *number* **Example:** `Device(config)# interface pseudowire 100`	Specifies the pseudowire interface and enters interface configuration mode.
Step 8	**encapsulation mpls** **Example:** `Device(config-if)# encapsulation mpls`	Specifies that Multiprotocol Label Switching (MPLS) is used as the data encapsulation method.
Step 9	**neighbor** *peer-address vcid-value* **Example:** `Device(config-if)# neighbor 10.13.13.13 100`	Specifies the peer IP address and virtual circuit (VC) ID value of the Layer 2 VPN (L2VPN) pseudowire.
Step 10	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode.
Step 11	**l2vpn xconnect context** *context-name* **Example:** `Device(config)# l2vpn xconnect context con1`	Creates a Layer 2 VPN (L2VPN) cross connect context and enters xconnect configuration mode.
Step 12	**member pseudowire** *interface-number* **Example:** `Device(config-xconnect)# member pseudowire 100`	Specifies a member pseudowire to form a Layer 2 VPN (L2VPN) cross connect.

	Command or Action	Purpose
Step 13	**member atm** *interface-number* **pvc** *vpi* / *vci* **Example:** `Device(config-xconnect)# member atm 100 pvc 1/200`	Specifies the location of the ATM member interface.
Step 14	**end** **Example:** `Device(config-xconnect)# end`	Exits to privileged EXEC mode.
Step 15	**show l2vpn atom vc** **Example:** `Device# show l2vpn atom vc`	Displays output that shows ATM AAL5 over MPLS is configured on a PVC.

Examples

The following is sample output from the **show l2vpn atom vc** command that shows that ATM AAL5 over MPLS is configured on a PVC:

```
Device# show l2vpn atom vc
Local intf   Local circuit          Dest address      VC ID      Status
---------    -------------          ------------      -----      ------
ATM1/0       ATM AAL5 1/100         10.4.4.4           100        UP
```

Configuring ATM AAL5 over MPLS in VC Class Configuration Mode

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vc-class atm** *vc-class-name*
4. **encapsulation** *layer-type*
5. **exit**
6. **interface** *type slot* / *subslot* / *port* [**.** *subinterface*]
7. **class-int** *vc-class-name*
8. **pvc** [*name*] *vpi* / *vci* **l2transport**
9. **xconnect** *peer-router-id vcid* **encapsulation mpls**
10. **end**
11. **show atm class-links**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Router> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**vc-class atm** *vc-class-name* **Example:** `Router(config)# vc-class atm aal5class`	Creates a VC class and enters VC class configuration mode.
Step 4	**encapsulation** *layer-type* **Example:** `Router(config-vc-class)# encapsulation aal5`	Configures the AAL and encapsulation type.
Step 5	**exit** **Example:** `Router(config-vc-class)# exit`	Exits VC class configuration mode.
Step 6	**interface** *type slot / subslot / port* [**.** *subinterface*] **Example:** `Router(config)# interface atm1/0/0`	Specifies the interface type enters interface configuration mode.
Step 7	**class-int** *vc-class-name* **Example:** `Router(config-if)# class-int aal5class`	Applies a VC class to the ATM main interface or subinterface. **Note** You can also apply a VC class to a PVC.
Step 8	**pvc** [*name*] *vpi / vci* **l2transport** **Example:** `Router(config-if)# pvc 1/200 l2transport`	Creates or assigns a name to an ATM PVC and enters L2transport PVC configuration mode. • The **l2transport** keyword indicates that the PVC is a switched PVC instead of a terminated PVC.
Step 9	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(config-if-atm-l2trans-pvc)# xconnect 10.13.13.13 100 encapsulation mpls`	Binds the attachment circuit to a pseudowire VC.
Step 10	**end** **Example:**	Exits to privileged EXEC mode.

	Command or Action	Purpose
	`Router(config-if-atm-l2trans-pvc)# end`	
Step 11	**show atm class-links** **Example:** `Router# show atm class-links`	Displays the type of encapsulation and that the VC class was applied to an interface.

Examples

In the following example, the command output from the **show atm class-links** command verifies that ATM AAL5 over MPLS is configured as part of a VC class. The command output shows the type of encapsulation and that the VC class was applied to an interface.

```
Router# show atm class-links 1/100
Displaying vc-class inheritance for ATM1/0/0.0, vc 1/100:
no broadcast - Not configured - using default
encapsulation aal5 - VC-class configured on main interface
```

Configuring ATM AAL5 over MPLS in VC Class Configuration Mode using the commands associated with the L2VPN Protocol-Based CLIs feature

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vc-class atm** *vc-class-name*
4. **encapsulation** *layer-type*
5. **exit**
6. **interface** *type slot* / *subslot* / *port* [**.** *subinterface*]
7. **class-int** *vc-class-name*
8. **pvc** [*name*] *vpi* / *vci* **l2transport**
9. **exit**
10. **interface pseudowire** *number*
11. **encapsulation mpls**
12. **neighbor** *peer-address vcid-value*
13. **exit**
14. **l2vpn xconnect context** *context-name*
15. **member pseudowire** *interface-number*
16. **member atm** *interface-number*
17. **end**
18. **show atm class-links**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**vc-class atm** *vc-class-name* **Example:** `Router(config)# vc-class atm aal5class`	Creates a VC class and enters VC class configuration mode.
Step 4	**encapsulation** *layer-type* **Example:** `Router(config-vc-class)# encapsulation aal5`	Configures the AAL and encapsulation type.
Step 5	**exit** **Example:** `Router(config-vc-class)# exit`	Exits VC class configuration mode.
Step 6	**interface** *type slot / subslot / port* [**.** *subinterface*] **Example:** `Router(config)# interface atm1/0/0`	Specifies the interface type enters interface configuration mode.
Step 7	**class-int** *vc-class-name* **Example:** `Router(config-if)# class-int aal5class`	Applies a VC class to the ATM main interface or subinterface. **Note** You can also apply a VC class to a PVC.
Step 8	**pvc** [*name*] *vpi* / *vci* **l2transport** **Example:** `Router(config-if)# pvc 1/200 l2transport`	Creates or assigns a name to an ATM PVC and enters L2transport PVC configuration mode. • The **l2transport** keyword indicates that the PVC is a switched PVC instead of a terminated PVC.
Step 9	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode.

	Command or Action	Purpose
Step 10	**interface pseudowire** *number* **Example:** `Router(config)# interface pseudowire 100`	Specifies the pseudowire interface and enters interface configuration mode.
Step 11	**encapsulation mpls** **Example:** `Router(config-if)# encapsulation mpls`	Specifies that Multiprotocol Label Switching (MPLS) is used as the data encapsulation method.
Step 12	**neighbor** *peer-address vcid-value* **Example:** `Router(config-if)# neighbor 10.0.0.1 123`	Specifies the peer IP address and virtual circuit (VC) ID value of the Layer 2 VPN (L2VPN) pseudowire.
Step 13	**exit** **Example:** `Router(config-if)# exit`	Exits interface configuration mode.
Step 14	**l2vpn xconnect context** *context-name* **Example:** `Router(config)# l2vpn xconnect context con1`	Creates a Layer 2 VPN (L2VPN) cross connect context and enters xconnect configuration mode.
Step 15	**member pseudowire** *interface-number* **Example:** `Router(config-xconnect)# member pseudowire 100`	Specifies a member pseudowire to form a Layer 2 VPN (L2VPN) cross connect.
Step 16	**member atm** *interface-number* **Example:** `Device(config-xconnect)# member atm 100`	Specifies the location of the ATM member interface.
Step 17	**end** **Example:** `Router(config-if-atm-l2trans-pvc)# end`	Exits to privileged EXEC mode.
Step 18	**show atm class-links** **Example:** `Router# show atm class-links`	Displays the type of encapsulation and that the VC class was applied to an interface.

Examples

In the following example, the command output from the **show atm class-links** command verifies that ATM AAL5 over MPLS is configured as part of a VC class. The command output shows the type of encapsulation and that the VC class was applied to an interface.

```
Router# show atm class-links 1/100
Displaying vc-class inheritance for ATM1/0/0.0, vc 1/100:
no broadcast - Not configured - using default
encapsulation aal5 - VC-class configured on main interface
```

Configuring Ethernet over MPLS

Configuring Ethernet over MPLS in Port Mode

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface gigabitethernet** *slot* / *subslot* / *port*
4. **no ip address**
5. **negotiation auto**
6. **service instance** *id* **ethernet**
7. **xconnect** *peer-router-id vcid* **encapsulation mpls**
8. **end**
9. **show mpls l2transport vc**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface gigabitethernet** *slot* / *subslot* / *port* **Example:** `Router(config)# interface gigabitethernet 0/2/4`	Specifies the Gigabit Ethernet interface and enters interface configuration mode.

	Command or Action	Purpose
Step 4	**no ip address** **Example:** `Router(config-if)# no ip address`	Specifies that there is no IP address assigned to the interface.
Step 5	**negotiation auto** **Example:** `Router(config-if)# negotiation auto`	Enables the auto negotiation protocol.
Step 6	**service instance** *id* **ethernet** **Example:** `Router(config-if)# service instance 100 ethernet`	Configures an ethernet service instance on an interface and enters service instance configuration mode.
Step 7	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(config-if)# xconnect 10.0.0.1 123 encapsulation mpls`	Binds the attachment circuit to a pseudowire VC.
Step 8	**end** **Example:** `Router(config-if)# end`	Exits to privileged EXEC mode.
Step 9	**show mpls l2transport vc** **Example:** `Router# show mpls l2transport vc`	Displays information about Ethernet over MPLS port mode.

Configuring Ethernet over MPLS in Port Mode Using Commands Associated with the L2VPN Protocol-Based Feature

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface gigabitethernet** *slot* **/** *subslot* **/** *port*[**.** *subinterface*]
4. **end**
5. **interface pseudowire** *number*
6. **encapsulation mpls**
7. **neighbor** *peer-address vcid-value*
8. **exit**
9. **l2vpn xconnect context** *context-name*
10. **member pseudowire** *interface-number*

11. **member gigabitethernet** *interface-number*
12. **end**
13. **end**
14. **show l2vpn atom vc**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface gigabitethernet** *slot* / *subslot* / *port*[**.** *subinterface*] **Example:** `Device(config)# interface gigabitethernet4/0/0`	Specifies the Gigabit Ethernet interface and enters interface configuration mode. • Make sure the interface on the adjoining CE router is on the same VLAN as this PE router.
Step 4	**end** **Example:** `Device(config-if)# end`	Exits to privileged EXEC mode.
Step 5	**interface pseudowire** *number* **Example:** `Device(config)# interface pseudowire 100`	Specifies the pseudowire interface and enters interface configuration mode.
Step 6	**encapsulation mpls** **Example:** `Device(config-if)# encapsulation mpls`	Specifies that Multiprotocol Label Switching (MPLS) is used as the data encapsulation method.
Step 7	**neighbor** *peer-address vcid-value* **Example:** `Device(config-if)# neighbor 10.0.0.1 123`	Specifies the peer IP address and virtual circuit (VC) ID value of the Layer 2 VPN (L2VPN) pseudowire.
Step 8	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode.

	Command or Action	Purpose
Step 9	**l2vpn xconnect context** *context-name* **Example:** `Device(config)# l2vpn xconnect context con1`	Creates a Layer 2 VPN (L2VPN) cross connect context and enters xconnect configuration mode.
Step 10	**member pseudowire** *interface-number* **Example:** `Device(config-xconnect)# member pseudowire 100`	Specifies a member pseudowire to form a Layer 2 VPN (L2VPN) cross connect.
Step 11	**member gigabitethernet** *interface-number* **Example:** `Device(config-xconnect)# member GigabitEthernet0/0/0.1`	Specifies the location of the Gigabit Ethernet member interface.
Step 12	**end** **Example:** `Device(config-xconnect)# end`	Exits to privileged EXEC mode.
Step 13	**end** **Example:** `Device(config-if)# end`	Exits to privileged EXEC mode.
Step 14	**show l2vpn atom vc** **Example:** `Device# show l2vpn atom vc`	Displays information about Ethernet over MPLS port mode.

Configuring Tunnel Selection

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **pseudowire-class** *name*
4. **encapsulation mpls**
5. **preferred-path** {**interface tunnel** *tunnel-number* | **peer**{*ip-address* | *host-name*}} [**disable-fallback**]
6. **exit**
7. **interface** *type slot / subslot / port*
8. **encapsulation** *encapsulation-type*
9. **xconnect** *peer-router-id vcid* **pw-class** *name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**pseudowire-class** *name* **Example:** `Router(config)# pseudowire-class ts1`	Establishes a pseudowire class with a name that you specify and enters pseudowire configuration mode.
Step 4	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation. For AToM, the encapsulation type is mpls.
Step 5	**preferred-path** {**interface tunnel** *tunnel-number* | **peer**{*ip-address* | *host-name*}} [**disable-fallback**] **Example:** `Router(config-pw)# preferred path peer 10.18.18.18`	Specifies the MPLS traffic engineering tunnel or IP address or hostname to be used as the preferred path.
Step 6	**exit** **Example:** `Router(config-pw)# exit`	Exits from pseudowire configuration mode and enables the Tunnel Selection feature.
Step 7	**interface** *type slot / subslot / port* **Example:** `Router(config)# interface atm1/1/0`	Specifies an interface type and enters interface configuration mode.
Step 8	**encapsulation** *encapsulation-type* **Example:** `Router(config-if)# encapsulation aal5`	Specifies the encapsulation for the interface.
Step 9	**xconnect** *peer-router-id vcid* **pw-class** *name* **Example:** `Router(config-if)# xconnect 10.0.0.1 123 pw-class ts1`	Binds the attachment circuit to a pseudowire VC.

Examples

In the following sample output from the **show mpls l2transport vc** command includes the following information about the VCs:

- VC 101 has been assigned a preferred path called Tunnel1. The default path is disabled, because the preferred path specified that the default path should not be used if the preferred path fails.
- VC 150 has been assigned an IP address of a loopback address on PE2. The default path can be used if the preferred path fails.

Command output that is in boldface font shows the preferred path information.

```
Router# show mpls l2transport vc detail
Local interface: Gi0/0/0.1 up, line protocol up, Eth VLAN 222 up
  Destination address: 10.16.16.16, VC ID: 101, VC status: up
    Preferred path: Tunnel1,  active
    Default path: disabled
    Tunnel label: 3, next hop point2point
    Output interface: Tu1, imposed label stack {17 16}
  Create time: 00:27:31, last status change time: 00:27:31
  Signaling protocol: LDP, peer 10.16.16.16:0 up
    MPLS VC labels: local 25, remote 16
    Group ID: local 0, remote 6
    MTU: local 1500, remote 1500
    Remote interface description:
  Sequencing: receive disabled, send disabled
  VC statistics:
    packet totals: receive 10, send 10
    byte totals:   receive 1260, send 1300
    packet drops:  receive 0, send 0
Local interface: ATM1/0/0 up, line protocol up, ATM AAL5 0/50 up
  Destination address: 10.16.16.16, VC ID: 150, VC status: up
    Preferred path: 10.18.18.18, active
    Default path: ready
    Tunnel label: 3, next hop point2point
    Output interface: Tu2, imposed label stack {18 24}
  Create time: 00:15:08, last status change time: 00:07:37
  Signaling protocol: LDP, peer 10.16.16.16:0 up
    MPLS VC labels: local 26, remote 24
    Group ID: local 2, remote 0
    MTU: local 4470, remote 4470
    Remote interface description:
  Sequencing: receive disabled, send disabled
  VC statistics:
    packet totals: receive 0, send 0
    byte totals:   receive 0, send 0
    packet drops:  receive 0, send 0
```

Troubleshooting Tips

To debug ATM cell packing, issue the **debug atm cell-packing** command.

Configuring Tunnel Selection Using Commands Associated with L2VPN Protocol-Based Feature

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **template type pseudowire** *name*
4. **encapsulation mpls**
5. **preferred-path** {**interface tunnel** *tunnel-number* | **peer** {*ip-address* | *hostname*}} [**disable-fallback**]
6. **exit**
7. **interface** *type slot* / *subslot* / *port*[**.** *subinterface*]
8. **encapsulation** *encapsulation-type*
9. **end**
10. **interface pseudowire** *number*
11. **source template type pseudowire** *name*
12. **neighbor** *peer-address vcid-value*
13. **end**
14. **l2vpn xconnect context** *context-name*
15. **member pseudowire** *interface-number*
16. **member** *ip-address vc-id* **encapsulation mpls**
17. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**template type pseudowire** *name* **Example:** `Router(config)# template type pseudowire ts1`	Creates a template pseudowire with a name that you specify and enters pseudowire configuration mode.
Step 4	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation. For AToM, the encapsulation type is mpls.

	Command or Action	Purpose
Step 5	**preferred-path** {**interface tunnel** *tunnel-number* | **peer** {*ip-address* | *hostname*}} [**disable-fallback**] **Example:** `Router(config-pw)# preferred path peer 10.18.18.18`	Specifies the MPLS traffic engineering tunnel or IP address or hostname to be used as the preferred path.
Step 6	**exit** **Example:** `Router(config-pw)# exit`	Exits from pseudowire configuration mode and enables the Tunnel Selection feature.
Step 7	**interface** *type slot* / *subslot* / *port*[**.** *subinterface*] **Example:** `Router(config)# interface atm1/1/0`	Specifies an interface type and enters interface configuration mode.
Step 8	**encapsulation** *encapsulation-type* **Example:** `Router(config-if)# encapsulation aal5`	Specifies the encapsulation for the interface.
Step 9	**end** **Example:** `Router(config-if)# end`	Exits to privileged EXEC mode.
Step 10	**interface pseudowire** *number* **Example:** `Router(config)# interface pseudowire 100`	Specifies the pseudowire interface and enters interface configuration mode.
Step 11	**source template type pseudowire** *name* **Example:** `Router(config-if)# source template type pseudowire ts1`	Configures the source template of type pseudowire named ts1.
Step 12	**neighbor** *peer-address vcid-value* **Example:** `Router(config-if)#  neighbor 10.0.0.1 123`	Specifies the peer IP address and virtual circuit (VC) ID value of a Layer 2 VPN (L2VPN) pseudowire.
Step 13	**end** **Example:** `Router(config-if)# end`	Exits to privileged EXEC mode.

	Command or Action	Purpose
Step 14	**l2vpn xconnect context** *context-name* **Example:** `Router(config)# l2vpn xconnect context con1`	Creates a Layer 2 VPN (L2VPN) cross connect context and enters xconnect configuration mode.
Step 15	**member pseudowire** *interface-number* **Example:** `Router(config-xconnect)# member pseudowire 100`	Specifies a member pseudowire to form a Layer 2 VPN (L2VPN) cross connect.
Step 16	**member** *ip-address vc-id* **encapsulation mpls** **Example:** `Router(config-xconnect)# member 10.0.0.1 123 encapsulation mpls`	Creates the VC to transport the Layer 2 packets.
Step 17	**end** **Example:** `Router(config-xconnect)# end`	Exits to privileged EXEC mode.

Troubleshooting Tips using the commands associated with the L2VPN Protocol-Based CLIs feature

You can use the **debug l2vpn atom vc event** command to troubleshoot tunnel selection. For example, if the tunnel interface that is used for the preferred path is shut down, the default path is enabled. The **debug l2vpn atom vc event** command provides the following output:

```
AToM SMGR [10.2.2.2, 101]: Processing imposition update, vc_handle 62091860, update_action
 3, remote_vc_label 16
AToM SMGR [10.2.2.2, 101]: selected route no parent rewrite: tunnel not up
AToM SMGR [10.2.2.2, 101]: Imposition Programmed, Output Interface: Et3/2
```

Setting Experimental Bits with AToM

Note Only EoMPLS and CEM is supported .

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **class-map** *class-name*
4. **match any**
5. **policy-map** *policy-name*
6. **class** *class-name*
7. **set mpls experimental** *value*

8. **exit**
9. **exit**
10. **interface** *type slot / subslot / port*
11. **service-policy input** *policy-name*
12. **end**
13. **show policy-map interface** *interface-name* [*vc* [*vpi* /] *vci*] [**dlci** *dlci*] [**input** | **output**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**class-map** *class-name* **Example:** `Router(config)# class-map class1`	Specifies the user-defined name of the traffic class and enters class map configuration mode.
Step 4	**match any** **Example:** `Router(config-cmap)# match any`	Specifies that all packets will be matched. Use only the **any** keyword. Other keywords might cause unexpected results.
Step 5	**policy-map** *policy-name* **Example:** `Router(config-cmap)# policy-map policy1`	Specifies the name of the traffic policy to configure and enters policy-map configuration mode.
Step 6	**class** *class-name* **Example:** `Router(config-pmap)# class class1`	Specifies the name of a predefined traffic class, which was configured with the **class-map** command, used to classify traffic to the traffic policy and enters policy-map class configuration mode.
Step 7	**set mpls experimental** *value* **Example:** `Router(config-pmap-c)# set mpls experimental 7`	Designates the value to which the MPLS bits are set if the packets match the specified policy map.
Step 8	**exit** **Example:**	Exits policy-map class configuration mode.

	Command or Action	Purpose
	`Router(config-pmap-c)# exit`	
Step 9	**exit** **Example:** `Router(config-pmap)# exit`	Exits policy-map configuration mode.
Step 10	**interface** *type slot / subslot / port* **Example:** `Router(config)# interface atm1/0/0`	Specifies the interface type and enters interface configuration mode.
Step 11	**service-policy input** *policy-name* **Example:** `Router(config-if)# service-policy input policy1`	Attaches a traffic policy to an interface.
Step 12	**end** **Example:** `Router(config-if)# end`	Exits to privileged EXEC mode.
Step 13	**show policy-map interface** *interface-name* [*vc* [*vpi* /] *vci*] [**dlci** *dlci*] [**input** | **output**] **Example:** `Router# show policy-map interface serial3/0/0`	Displays the traffic policy attached to an interface.

Enabling the Control Word

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **pseudowire-class cw_enable**
4. **encapsulation mpls**
5. **control-word**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
	`Router> enable`	
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**pseudowire-class cw_enable** **Example:** `Router(config)# pseudowire-class cw_enable`	Enters pseudowire class configuration mode.
Step 4	**encapsulation mpls** **Example:** `Router(config-pw-class)# encapsulation mpls`	Specifies the tunneling encapsulation. • For AToM, the encapsulation type is MPLS.
Step 5	**control-word** **Example:** `Router(config-pw-class)# control-word`	Enables the control word.
Step 6	**end** **Example:** `Router(config-pw-class)# end`	Exits to privileged EXEC mode.

Enabling the Control Word using the commands associated with the L2VPN Protocol-Based CLIs feature

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface pseudowire** *number*
4. **encapsulation mpls**
5. **control-word include**
6. **neighbor** *peer-address vcid-value*
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Router> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface pseudowire** *number* **Example:** `Router(config)# interface pseudowire 1`	Creates an interface pseudowire with a value that you specify and enters pseudowire configuration mode.
Step 4	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation. • For AToM, the encapsulation type is mpls.
Step 5	**control-word include** **Example:** `Router(config-pw)# control-word include`	Enables the control word.
Step 6	**neighbor** *peer-address vcid-value* **Example:** `Router(config-pw)#  neighbor 10.0.0.1 123`	Specifies the peer IP address and virtual circuit (VC) ID value of a Layer 2 VPN (L2VPN) pseudowire.
Step 7	**end** **Example:** `Router(config-pw)# end`	Exits to privileged EXEC mode.

Configuring MPLS AToM Remote Ethernet Port Shutdown

Note The Any Transport over MPLS (AToM): Remote Ethernet Port Shutdown feature is automatically enabled by default when an image with the feature supported is loaded on the router.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **pseudowire-class** [*pw-class-name*]

4. **encapsulation mpls**
5. **exit**
6. **interface** *type slot / subslot / port*
7. **service instance** *number* **ethernet** *number*
8. **encapsulation** *default*
9. **xconnect** *peer-ip-address vc-id pw-class pw-class-name*
10. **no remote link failure notification**
11. **remote link failure notification**
12. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**pseudowire-class** [*pw-class-name*] **Example:** `Router(config)# pseudowire-class eompls`	Specifies the name of a Layer 2 pseudowire class and enters pseudowire class configuration mode.
Step 4	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies that MPLS is used as the data encapsulation method for tunneling Layer 2 traffic over the pseudowire.
Step 5	**exit** **Example:** `Router(config-pw)# exit`	Exits to global configuration mode.
Step 6	**interface** *type slot / subslot / port* **Example:** `Router (config)# interface GigabitEthernet1/0/0`	Configures an interface type and enters interface configuration mode.
Step 7	**service instance** *number* **ethernet** *number* **Example:** `Router(config-if)# service instance 393 ethernet`	Configures an ethernet service instance on an interface and enters service instance configuration mode.

	Command or Action	Purpose
Step 8	**encapsulation** *default* **Example:** `Router(config-if-srv)# encapsulation default`	Specifies the encapsulation type for the interface, such as dot1q. **Note** Remote ethernet port shutdown is supported only with encapsulation default.
Step 9	**xconnect** *peer-ip-address vc-id pw-class pw-class-name* **Example:** `Router(config-if)# xconnect 10.1.1.1 1 pw-class eompls`	Binds an attachment circuit to a pseudowire, and configures an Any Transport over MPLS (AToM) static pseudowire.
Step 10	**no remote link failure notification** **Example:** `Router(config-if-xconn)# remote link failure notification`	Disables MPLS AToM remote link failure notification and shutdown.
Step 11	**remote link failure notification** **Example:** `Router(config-if-xconn)# remote link failure notification`	Enables MPLS AToM remote link failure notification and shutdown.
Step 12	**end** **Example:** `Router(config-if-xconn)# end`	Exits to privileged EXEC mode.

Configuring MPLS AToM Remote Ethernet Port Shutdown using the commands associated with the L2VPN Protocol-Based CLIs feature

Note The Any Transport over MPLS (AToM): Remote Ethernet Port Shutdown feature is automatically enabled by default when an image with the feature supported is loaded on the router.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **template type pseudowire** [*pseudowire-name*]
4. **encapsulation mpls**
5. **exit**
6. **interface** *type slot / subslot / port*

7. **interface pseudowire** *number*
8. **source template type pseudowire**
9. **neighbor** *peer-address vcid-value*
10. **end**
11. **l2vpn xconnect context** *context-name*
12. **no remote link failure notification**
13. **remote link failure notification**
14. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**template type pseudowire** [*pseudowire-name*] **Example:** `Device(config)# template type pseudowire eompls`	Specifies the name of a Layer 2 pseudowire class and enters pseudowire class configuration mode.
Step 4	**encapsulation mpls** **Example:** `Device(config-pw)# encapsulation mpls`	Specifies that MPLS is used as the data encapsulation method for tunneling Layer 2 traffic over the pseudowire.
Step 5	**exit** **Example:** `Device(config-pw)# exit`	Exits to global configuration mode.
Step 6	**interface** *type slot / subslot / port* **Example:** `Device(config)# interface GigabitEthernet1/0/0`	Configures an interface type and enters interface configuration mode.
Step 7	**interface pseudowire** *number* **Example:** `Device(config-if)# interface pseudowire 100`	Specifies the pseudowire interface.

	Command or Action	Purpose
Step 8	**source template type pseudowire** **Example:** `Device(config-if)# source template type pseudowire eompls`	Configures the source template of type pseudowire named eompls.
Step 9	**neighbor** *peer-address vcid-value* **Example:** `Device(config-if)# neighbor 10.1.1.1 1`	Specifies the peer IP address and virtual circuit (VC) ID value of a Layer 2 VPN (L2VPN) pseudowire.
Step 10	**end** **Example:** `Device(config-if)# end`	Exits to privileged EXEC mode.
Step 11	**l2vpn xconnect context** *context-name* **Example:** `Device(config)# l2vpn xconnect context con1`	Creates a Layer 2 VPN (L2VPN) cross connect context and enters xconnect configuration mode.
Step 12	**no remote link failure notification** **Example:** `Device(config-xconnect)# no remote link failure notification`	Disables MPLS AToM remote link failure notification and shutdown.
Step 13	**remote link failure notification** **Example:** `Device(config-xconnect)# remote link failure notification`	Enables MPLS AToM remote link failure notification and shutdown.
Step 14	**end** **Example:** `Device(config-xconnect)# end`	Exits to privileged EXEC mode.

Configuration Examples for Any Transport over MPLS

Example: ATM over MPLS

The table below shows the configuration of ATM over MPLS on two PE routers.

Table 7: ATM over MPLS Configuration Example

PE1	PE2
mpls label protocol ldp mpls ldp router-id Loopback0 force ! interface Loopback0 ip address 10.16.12.12 255.255.255.255 ! interface ATM4/0/0 pvc 0/100 l2transport encapsulation aal0 xconnect 10.13.13.13 100 encapsulation mpls ! interface ATM4/0/0.300 point-to-point no ip directed-broadcast no atm enable-ilmi-trap pvc 0/300 l2transport encapsulation aal0 xconnect 10.13.13.13 300 encapsulation mpls	mpls label protocol ldp mpls ldp router-id Loopback0 force ! interface Loopback0 ip address 10.13.13.13 255.255.255.255 interface ATM4/0/0 pvc 0/100 l2transport encapsulation aal0 xconnect 10.16.12.12 100 encapsulation mpls ! interface ATM4/0/0.300 point-to-point no ip directed-broadcast no atm enable-ilmi-trap pvc 0/300 l2transport encapsulation aal0 xconnect 10.16.12.12 300 encapsulation mpls

Example: ATM over MPLS Using Commands Associated with L2VPN Protocol-Based Feature

The table below shows the configuration of ATM over MPLS on two PE routers.

Table 8: ATM over MPLS Configuration Example

PE1	PE2

PE1	PE2
mpls label protocol ldp	mpls label protocol ldp
mpls ldp router-id Loopback0 force	mpls ldp router-id Loopback0 force
!	!
interface Loopback0	interface Loopback0
ip address 10.16.12.12 255.255.255.255	ip address 10.13.13.13 255.255.255.255
!	
interface ATM4/0/0	interface ATM4/0/0
pvc 0/100 l2transport	pvc 0/100 l2transport
encapsulation aal0	encapsulation aal0
interface pseudowire 100	interface pseudowire 100
encapsulation mpls	encapsulation mpls
neighbor 10.0.0.1 123	neighbor 10.0.0.1 123
!	!
l2vpn xconnect context A	l2vpn xconnect context A
member pseudowire 100	member pseudowire 100
member atm 100	member atm 100
!	!
interface ATM4/0/0.300 point-to-point	interface ATM4/0/0.300 point-to-point
no atm enable-ilmi-trap	no ip directed-broadcast
pvc 0/300 l2transport	no atm enable-ilmi-trap
encapsulation aal0	pvc 0/300 l2transport
interface pseudowire 300	encapsulation aal0
encapsulation mpls	interface pseudowire 300
neighbor 10.0.0.1 123	encapsulation mpls

PE1	PE2
!	neighbor 10.0.0.1 123
l2vpn xconnect context A	!
member pseudowire 300	l2vpn xconnect context A
member atm 300	member pseudowire 300
	member atm 300

Example: Configuring ATM AAL5 over MPLS in VC Class Configuration Mode

The following example configures ATM AAL5 over MPLS in VC class configuration mode. The VC class is then applied to an interface.

```
enable
configure terminal
vc-class atm aal5class
encapsulation aal5
interface atm1/0/0
class-int aal5class
pvc 1/200 l2transport
xconnect 10.13.13.13 100 encapsulation mpls
```

The following example configures ATM AAL5 over MPLS in VC class configuration mode. The VC class is then applied to a PVC.

```
enable
configure terminal
vc-class atm aal5class
encapsulation aal5
interface atm1/0/0
pvc 1/200 l2transport
class-vc aal5class
xconnect 10.13.13.13 100 encapsulation mpls
```

Example: Configuring ATM AAL5 over MPLS in VC Class Configuration Mode Using Commands Associated with L2VPN Protocol-Based Feature

The following example configures ATM AAL5 over MPLS in VC class configuration mode. The VC class is then applied to an interface.

```
enable
configure terminal
vc-class atm aal5class
encapsulation aal5
interface atm1/0/0
class-int aal5class
pvc 1/200 l2transport
interface pseudowire 100
encapsulation mpls
```

```
neighbor 10.0.0.1 123
exit
l2vpn xconnect context A
member pseudowire 100
member atm 100
exit
```

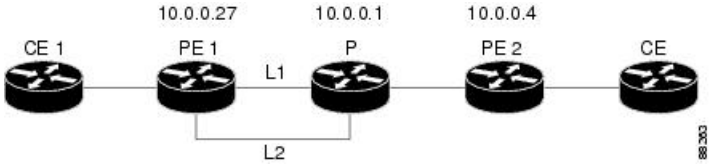
Example: Ethernet over MPLS with MPLS Traffic Engineering Fast Reroute

The following configuration example and the figure show the configuration of Ethernet over MPLS with fast reroute on AToM PE routers.

Routers PE1 and PE2 have the following characteristics:

- A TE tunnel called Tunnel41 is configured between PE1and PE2, using an explicit path through a link called L1. AToM VCs are configured to travel through the FRR-protected tunnel Tunnel41.
- The link L1 is protected by FRR, the backup tunnel is Tunnel1.
- PE2 is configured to forward the AToM traffic back to PE1 through the L2 link.

Figure 3: Fast Reroute Configuration



PE1 Configuration

```
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ldp router-id Loopback1 force
!
pseudowire-class T41
 encapsulation mpls
 preferred-path interface Tunnel41 disable-fallback
!
pseudowire-class IP1
 encapsulation mpls
 preferred-path peer 10.4.0.1 disable-fallback
!
interface Loopback1
 ip address 10.0.0.27 255.255.255.255
!
interface Tunnel1
 ip unnumbered Loopback1
 tunnel destination 10.0.0.1
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth 10000
 tunnel mpls traffic-eng path-option 1 explicit name FRR
!
interface Tunnel41
 ip unnumbered Loopback1
 tunnel destination 10.0.0.4
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth 1000
```

```
 tunnel mpls traffic-eng path-option 1 explicit name name-1
 tunnel mpls traffic-eng fast-reroute
!
interface POS0/0/0
 description pe1name POS8/0/0
 ip address 10.1.0.2 255.255.255.252
 mpls traffic-eng tunnels
 mpls traffic-eng backup-path Tunnel1
 crc 16
 clock source internal
 pos ais-shut
 pos report lrdi
 ip rsvp bandwidth 155000 155000
!
interface POS0/3/0
 description pe1name POS10/1/0
 ip address 10.1.0.14 255.255.255.252
 mpls traffic-eng tunnels
 crc 16
 clock source internal
 ip rsvp bandwidth 155000 155000
!
interface gigabitethernet3/0/0.1
 encapsulation dot1Q 203
 xconnect 10.0.0.4 2 pw-class IP1
!
interface gigabitethernet3/0/0.2
 encapsulation dot1Q 204
 xconnect 10.0.0.4 4 pw-class T41
!
router ospf 1
 network 10.0.0.0 0.255.255.255 area 0
 mpls traffic-eng router-id Loopback1
 mpls traffic-eng area 0
!
ip classless
ip route 10.4.0.1 255.255.255.255 Tunnel41
!
ip explicit-path name xxxx-1 enable
 next-address 10.4.1.2
 next-address 10.1.0.10
```

P Configuration

```
ip cef
mpls traffic-eng tunnels
!
interface Loopback1
 ip address 10.0.0.1 255.255.255.255
!
interface FastEthernet1/0/0
 ip address 10.4.1.2 255.255.255.0
 mpls traffic-eng tunnels
 ip rsvp bandwidth 10000 10000
!
interface POS8/0/0
 description xxxx POS0/0
 ip address 10.1.0.1 255.255.255.252
 mpls traffic-eng tunnels
 pos ais-shut
 pos report lrdi
 ip rsvp bandwidth 155000 155000
!
```

```
interface POS10/1/0
 description xxxx POS0/3
 ip address 10.1.0.13 255.255.255.252
 mpls traffic-eng tunnels
 ip rsvp bandwidth 155000 155000
!
router ospf 1
 network 10.0.0.0 0.255.255.255 area 0
 mpls traffic-eng router-id Loopback1
 mpls traffic-eng area 0
```

PE2 Configuration

```
ip cef
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ldp router-id Loopback1 force
!
interface Loopback1
 ip address 10.0.0.4 255.255.255.255
!
interface loopback 2
ip address 10.4.0.1 255.255.255.255
!
interface Tunnel27
 ip unnumbered Loopback1
 tunnel destination 10.0.0.27
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth 1000
 tunnel mpls traffic-eng path-option 1 explicit name xxxx-1
!
interface FastEthernet0/0/0.2
 encapsulation dot1Q 203
 xconnect 10.0.0.27 2 encapsulation mpls
!
interface FastEthernet0/0/0.3
 encapsulation dot1Q 204
 xconnect 10.0.0.27 4 encapsulation mpls
!
interface FastEthernet1/1/0
 ip address 10.4.1.1 255.255.255.0
 mpls traffic-eng tunnels
 ip rsvp bandwidth 10000 10000
!
router ospf 1
 network 10.0.0.0 0.255.255.255 area 0
 mpls traffic-eng router-id Loopback1
 mpls traffic-eng area 0
!
ip explicit-path name xxxx-1 enable
 next-address 10.4.1.2
 next-address 10.1.0.10
```

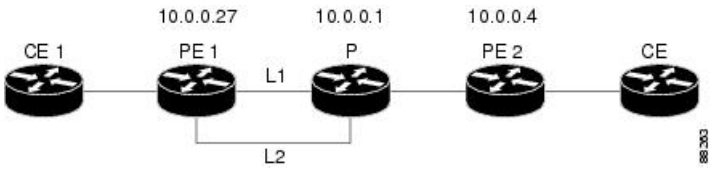
Example: Ethernet over MPLS with MPLS Traffic Engineering Fast Reroute Using Commands Associated with L2VPN Protocol-Based Feature

The following configuration example and the figure show the configuration of Ethernet over MPLS with fast reroute on AToM PE routers.

Routers PE1 and PE2 have the following characteristics:

- A TE tunnel called Tunnel41 is configured between PE1and PE2, using an explicit path through a link called L1. AToM VCs are configured to travel through the FRR-protected tunnel Tunnel41.
- The link L1 is protected by FRR, the backup tunnel is Tunnel1.
- PE2 is configured to forward the AToM traffic back to PE1 through the L2 link.

Figure 4: Fast Reroute Configuration



PE1 Configuration

```
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ldp router-id Loopback1 force
!
template type pseudowire T41
 encapsulation mpls
 preferred-path interface Tunnel41 disable-fallback
!
template type pseudowire IP1
 encapsulation mpls
 preferred-path peer 10.4.0.1 disable-fallback
!
interface Loopback1
 ip address 10.0.0.27 255.255.255.255
!
interface Tunnel1
 ip unnumbered Loopback1
 tunnel destination 10.0.0.1
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth 10000
 tunnel mpls traffic-eng path-option 1 explicit name FRR
!
interface Tunnel41
 ip unnumbered Loopback1
 tunnel destination 10.0.0.4
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth 1000
 tunnel mpls traffic-eng path-option 1 explicit name name-1
 tunnel mpls traffic-eng fast-reroute
!
interface POS0/0/0
 description pe1name POS8/0/0
 ip address 10.1.0.2 255.255.255.252
 mpls traffic-eng tunnels
 mpls traffic-eng backup-path Tunnel1
 crc 16
 clock source internal
 pos ais-shut
 pos report lrdi
 ip rsvp bandwidth 155000 155000
```

```
!
interface POS0/3/0
 description pe1name POS10/1/0
 ip address 10.1.0.14 255.255.255.252
 mpls traffic-eng tunnels
 crc 16
 clock source internal
 ip rsvp bandwidth 155000 155000
!
interface gigabitethernet3/0/0.1
 encapsulation dot1Q 203
 interface pseudowire 100
 source template type pseudowire T41
 neighbor 10.0.0.4 2
!
l2vpn xconnect context con1
!
interface gigabitethernet3/0/0.2
 encapsulation dot1Q 204
 interface pseudowire 100
 source template type pseudowire IP1
 neighbor 10.0.0.4 4
!
l2vpn xconnect context con2
!
router ospf 1
 network 10.0.0.0 0.255.255.255 area 0
 mpls traffic-eng router-id Loopback1
 mpls traffic-eng area 0
!
ip classless
ip route 10.4.0.1 255.255.255.255 Tunnel41
!
ip explicit-path name xxxx-1 enable
 next-address 10.4.1.2
 next-address 10.1.0.10
```

P Configuration

```
ip cef
mpls traffic-eng tunnels
!
interface Loopback1
 ip address 10.0.0.1 255.255.255.255
!
interface FastEthernet1/0/0
 ip address 10.4.1.2 255.255.255.0
 mpls traffic-eng tunnels
 ip rsvp bandwidth 10000 10000
!
interface POS8/0/0
 description xxxx POS0/0
 ip address 10.1.0.1 255.255.255.252
 mpls traffic-eng tunnels
 pos ais-shut
 pos report lrdi
 ip rsvp bandwidth 155000 155000
!
interface POS10/1/0
 description xxxx POS0/3
 ip address 10.1.0.13 255.255.255.252
 mpls traffic-eng tunnels
 ip rsvp bandwidth 155000 155000
```

```
!
router ospf 1
 network 10.0.0.0 0.255.255.255 area 0
 mpls traffic-eng router-id Loopback1
 mpls traffic-eng area 0
```

PE2 Configuration

```
ip cef
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ldp router-id Loopback1 force
!
interface Loopback1
 ip address 10.0.0.4 255.255.255.255
!
interface loopback 2
ip address 10.4.0.1 255.255.255.255
!
interface Tunnel27
 ip unnumbered Loopback1
 tunnel destination 10.0.0.27
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth 1000
 tunnel mpls traffic-eng path-option 1 explicit name xxxx-1
!
interface FastEthernet0/0/0.2
 encapsulation dot1Q 203
 interface pseudowire 100
 encapsulation mpls
 neighbor 10.0.0.1 123
!
l2vpn xconnect context A
 member pseudowire 100
 member gigabitethernet 0/0/0.1
!
interface FastEthernet0/0/0.3
 encapsulation dot1Q 204
 interface pseudowire 100
 encapsulation mpls
 neighbor 10.0.0.1 123
!
l2vpn xconnect context A
 member pseudowire 100
 member gigabitethernet 0/0/0.1
!
interface FastEthernet1/1/0
 ip address 10.4.1.1 255.255.255.0
 mpls traffic-eng tunnels
 ip rsvp bandwidth 10000 10000
!
router ospf 1
 network 10.0.0.0 0.255.255.255 area 0
 mpls traffic-eng router-id Loopback1
 mpls traffic-eng area 0
!
ip explicit-path name xxxx-1 enable
 next-address 10.4.1.2
 next-address 10.1.0.10
```

Example: Configuring Tunnel Selection

The following example shows how to set up two preferred paths for PE1. One preferred path specifies an MPLS traffic engineering tunnel. The other preferred path specifies an IP address of a loopback address on PE2. There is a static route configured on PE1 that uses a TE tunnel to reach the IP address on PE2.

PE1 Configuration

```
mpls label protocol ldp
mpls traffic-eng tunnels
tag-switching tdp router-id Loopback0
pseudowire-class pw1
 encapsulation mpls
 preferred-path interface Tunnel1 disable-fallback
!
pseudowire-class pw2
 encapsulation mpls
 preferred-path peer 10.18.18.18
!
interface Loopback0
 ip address 10.2.2.2 255.255.255.255
 no ip directed-broadcast
 no ip mroute-cache
!
interface Tunnel1
 ip unnumbered Loopback0
 no ip directed-broadcast
 tunnel destination 10.16.16.16
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 1500
 tunnel mpls traffic-eng path-option 1 explicit name path-tu1
!
interface Tunnel2
 ip unnumbered Loopback0
 no ip directed-broadcast
 tunnel destination 10.16.16.16
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 1500
 tunnel mpls traffic-eng path-option 1 dynamic
!
interface gigabitethernet0/0/0
 no ip address
 no ip directed-broadcast
 no negotiation auto
!
interface gigabitethernet0/0/0.1
 encapsulation dot1Q 222
 no ip directed-broadcast
 xconnect 10.16.16.16 101 pw-class pw1
!
interface ATM1/0/0
 no ip address
 no ip directed-broadcast
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
 pvc 0/50 l2transport
  encapsulation aal5
  xconnect 10.16.16.16 150 pw-class pw2
!
```

```
interface FastEthernet2/0/1
 ip address 10.0.0.1 255.255.255.0
 no ip directed-broadcast
 tag-switching ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 15000 15000
!
router ospf 1
 log-adjacency-changes
 network 10.0.0.0 0.0.0.255 area 0
 network 10.2.2.2 0.0.0.0 area 0
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
!
ip route 10.18.18.18 255.255.255.255 Tunnel2
!
ip explicit-path name path-tu1 enable
 next-address 10.0.0.1
 index 3 next-address 10.0.0.1
```

PE2 Configuration

```
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ldp router-id Loopback0
interface Loopback0
 ip address 10.16.16.16 255.255.255.255
 no ip directed-broadcast
 no ip mroute-cache
!
interface Loopback2
 ip address 10.18.18.18 255.255.255.255
 no ip directed-broadcast
!
interface FastEthernet1/1/0
 ip address 10.0.0.2 255.255.255.0
 no ip directed-broadcast
 mpls traffic-eng tunnels
 mpls ip
 no cdp enable
 ip rsvp bandwidth 15000 15000
!
interface FastEthernet1/1/1
 no ip address
 no ip directed-broadcast
 no cdp enable
!
interface FastEthernet1/1/1.1
 encapsulation dot1Q 222
 no ip directed-broadcast
 no cdp enable
 mpls l2transport route 10.2.2.2 101
!
interface ATM5/0/0
 no ip address
 no ip directed-broadcast
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
 pvc 0/50 l2transport
  encapsulation aal5
  xconnect 10.2.2.2 150 encapsulation mpls
!
router ospf 1
```

```
 log-adjacency-changes
 network 10.0.0.0 0.0.0.255 area 0
 network 10.16.16.16 0.0.0.0 area 0
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
```

Example: Configuring Tunnel Selection Using Commands Associated with L2VPN Protocol-Based Feature

The following example shows how to set up two preferred paths for PE1. One preferred path specifies an MPLS traffic engineering tunnel. The other preferred path specifies an IP address of a loopback address on PE2. There is a static route configured on PE1 that uses a TE tunnel to reach the IP address on PE2.

PE1 Configuration

```
mpls label protocol ldp
mpls traffic-eng tunnels
tag-switching tdp router-id Loopback0
template type pseudowire pw1
 encapsulation mpls
 preferred-path interface Tunnel1 disable-fallback
!
template type pseudowire pw2
 encapsulation mpls
 preferred-path peer 10.18.18.18
!
interface Loopback0
 ip address 10.2.2.2 255.255.255.255
 no ip directed-broadcast
 no ip mroute-cache
!
interface Tunnel1
 ip unnumbered Loopback0
 no ip directed-broadcast
 tunnel destination 10.16.16.16
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 1500
 tunnel mpls traffic-eng path-option 1 explicit name path-tu1
!
interface Tunnel2
 ip unnumbered Loopback0
 no ip directed-broadcast
 tunnel destination 10.16.16.16
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 1500
 tunnel mpls traffic-eng path-option 1 dynamic
!
interface gigabitethernet0/0/0
 no ip address
 no ip directed-broadcast
 no negotiation auto
!
interface gigabitethernet0/0/0.1
 encapsulation dot1Q 222
 no ip directed-broadcast
 interface pseudowire 100
 source template type pseudowire pw1
```

```
  neighbor 10.16.16.16 101
!
l2vpn xconnect context con1
!
interface ATM1/0/0
 no ip address
 no ip directed-broadcast
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
 pvc 0/50 l2transport
  encapsulation aal5
 interface pseudowire 100
 source template type pseudowire pw2
 neighbor 10.16.16.16 150
!
l2vpn xconnect context con1
!
interface FastEthernet2/0/1
 ip address 10.0.0.1 255.255.255.0
 no ip directed-broadcast
 tag-switching ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 15000 15000
!
router ospf 1
 log-adjacency-changes
 network 10.0.0.0 0.0.0.255 area 0
 network 10.2.2.2 0.0.0.0 area 0
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
!
ip route 10.18.18.18 255.255.255.255 Tunnel2
!
ip explicit-path name path-tu1 enable
 next-address 10.0.0.1
 index 3 next-address 10.0.0.1
```

PE2 Configuration

```
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ldp router-id Loopback0
interface Loopback0
 ip address 10.16.16.16 255.255.255.255
 no ip directed-broadcast
 no ip mroute-cache
!
interface Loopback2
 ip address 10.18.18.18 255.255.255.255
 no ip directed-broadcast
!
interface FastEthernet1/1/0
 ip address 10.0.0.2 255.255.255.0
 no ip directed-broadcast
 mpls traffic-eng tunnels
 mpls ip
 no cdp enable
 ip rsvp bandwidth 15000 15000
!
interface FastEthernet1/1/1
 no ip address
 no ip directed-broadcast
 no cdp enable
```

```
!
interface FastEthernet1/1/1.1
 encapsulation dot1Q 222
 no ip directed-broadcast
 no cdp enable
 mpls l2transport route 10.2.2.2 101
!
interface ATM5/0/0
 no ip address
 no ip directed-broadcast
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
 pvc 0/50 l2transport
  encapsulation aal5
  interface pseudowire 100
   encapsulation mpls
   neighbor 10.2.2.2 150
!
l2vpn xconnect context A
  member pseudowire 100
  member GigabitEthernet0/0/0.1
!
router ospf 1
 log-adjacency-changes
 network 10.0.0.0 0.0.0.255 area 0
 network 10.16.16.16 0.0.0.0 area 0
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
```

Example: Configuring MTU Values in xconnect Configuration Mode for L2VPN Interworking

The following example shows an L2VPN Interworking example. The PE1 router has a serial interface configured with an MTU value of 1492 bytes. The PE2 router uses xconnect configuration mode to set a matching MTU of 1492 bytes, which allows the two routers to form an interworking VC. If the PE2 router did not set the MTU value in xconnect configuration mode, the interface would be set to 1500 bytes by default and the VC would not come up.

Note L2VPN interworking is not supported on Cisco ASR 900 RSP3 Module.

PE1 Configuration

```
pseudowire-class atom-ipiw
 encapsulation mpls
 interworking ip
!
interface Loopback0
 ip address 10.1.1.151 255.255.255.255
!
interface Serial2/0/0
 mtu 1492
 no ip address
 encapsulation ppp
 no fair-queue
 serial restart-delay 0
```

```
 xconnect 10.1.1.152 123 pw-class atom-ipiw
!
interface Serial4/0/0
 ip address 10.151.100.1 255.255.255.252
 encapsulation ppp
 mpls ip
 serial restart-delay 0
!
router ospf 1
 log-adjacency-changes
 network 10.1.1.151 0.0.0.0 area 0
 network 10.151.100.0 0.0.0.3 area 0
!
mpls ldp router-id Loopback0
```

PE2 Configuration

```
pseudowire-class atom-ipiw
 encapsulation mpls
 interworking ip
!
interface Loopback0
 ip address 10.1.1.152 255.255.255.255
!
interface FastEthernet0/0/0
 no ip address
 xconnect 10.1.1.151 123 pw-class atom-ipiw
  mtu 1492
!
interface Serial4/0/0
 ip address 10.100.152.2 255.255.255.252
 encapsulation ppp
 mpls ip
 serial restart-delay 0
!
router ospf 1
 log-adjacency-changes
 network 10.1.1.152 0.0.0.0 area 0
 network 10.100.152.0 0.0.0.3 area 0
!
mpls ldp router-id Loopback0
```

The **show mpls l2transport binding** command shows that the MTU value for the local and remote routers is 1492 bytes.

PE1

```
Router# show mpls l2transport binding
Destination Address: 10.1.1.152,  VC ID: 123
    Local Label: 105
        Cbit: 1,    VC Type: PPP,    GroupID: 0
        MTU: 1492,   Interface Desc: n/a
        VCCV: CC Type: CW [1], RA [2]
              CV Type: LSPV [2]
    Remote Label: 205
        Cbit: 1,    VC Type: FastEthernet,    GroupID: 0
        MTU: 1492,   Interface Desc: n/a
        VCCV: CC Type: RA [2]
              CV Type: LSPV [2]
Router# show mpls l2transport vc detail
Local interface: Serial2/0/0 up, line protocol up, PPP up
```

```
  MPLS VC type is PPP, interworking type is IP
  Destination address: 10.1.1.152, VC ID: 123, VC status: up
    Output interface: Serial4/0/0, imposed label stack {1003 205}
    Preferred path: not configured
    Default path: active
    Next hop: point2point
  Create time: 00:25:29, last status change time: 00:24:54
  Signaling protocol: LDP, peer 10.1.1.152:0 up
    Targeted Hello: 10.1.1.151(LDP Id) -> 10.1.1.152
    Status TLV support (local/remote)   : enabled/supported
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: no fault
      Last local SSS circuit status rcvd: no fault
      Last local SSS circuit status sent: no fault
      Last local  LDP TLV    status sent: no fault
      Last remote LDP TLV    status rcvd: no fault
    MPLS VC labels: local 105, remote 205
    Group ID: local n/a, remote 0
    MTU: local 1492, remote 1492
    Remote interface description:
  Sequencing: receive disabled, send disabled
  VC statistics:
    packet totals: receive 30, send 29
    byte totals:   receive 2946, send 3364
    packet drops:  receive 0, send 0
```

PE2

```
Router# show mpls l2transport binding
Destination Address: 10.1.1.151,  VC ID: 123
    Local Label: 205
        Cbit: 1,    VC Type: FastEthernet,    GroupID: 0
        MTU: 1492,   Interface Desc: n/a
        VCCV: CC Type: RA [2]
              CV Type: LSPV [2]
    Remote Label: 105
        Cbit: 1,    VC Type: FastEthernet,    GroupID: 0
        MTU: 1492,   Interface Desc: n/a
        VCCV: CC Type: CW [1], RA [2]
              CV Type: LSPV [2]
Router# show mpls l2transport vc detail
Local interface: Fe0/0/0 up, line protocol up, FastEthernet up
  MPLS VC type is FastEthernet, interworking type is IP
  Destination address: 10.1.1.151, VC ID: 123, VC status: up
    Output interface: Se4/0/0, imposed label stack {1002 105}
    Preferred path: not configured
    Default path: active
    Next hop: point2point
  Create time: 00:25:19, last status change time: 00:25:19
  Signaling protocol: LDP, peer 10.1.1.151:0 up
    Targeted Hello: 10.1.1.152(LDP Id) -> 10.1.1.151
    Status TLV support (local/remote)   : enabled/supported
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: no fault
      Last local SSS circuit status rcvd: no fault
      Last local SSS circuit status sent: no fault
      Last local  LDP TLV    status sent: no fault
      Last remote LDP TLV    status rcvd: no fault
    MPLS VC labels: local 205, remote 105
    Group ID: local n/a, remote 0
    MTU: local 1492, remote 1492
    Remote interface description:
  Sequencing: receive disabled, send disabled
```

```
  VC statistics:
    packet totals: receive 29, send 30
    byte totals:   receive 2900, send 3426
    packet drops:  receive 0, send 0
```

Example: Configuring MTU Values in xconnect Configuration Mode for L2VPN Interworking Using Commands Associated with L2VPN Protocol-Based Feature

The following example shows an L2VPN Interworking example. The PE1 router has a serial interface configured with an MTU value of 1492 bytes. The PE2 router uses xconnect configuration mode to set a matching MTU of 1492 bytes, which allows the two routers to form an interworking VC. If the PE2 router did not set the MTU value in xconnect configuration mode, the interface would be set to 1500 bytes by default and the VC would not come up.

PE1 Configuration

```
template type pseudowire atom-ipiw
 encapsulation mpls
 interworking ip
!
interface Loopback0
 ip address 10.1.1.151 255.255.255.255
!
interface Serial2/0/0
 mtu 1492
 no ip address
 encapsulation ppp
 no fair-queue
 serial restart-delay 0
interface pseudowire 100
 source template type pseudowire atom-ipiw
 neighbor 10.1.1.152 123
!
l2vpn xconnect context con1
 member <ac_int>
 member pseudowire 100
!
interface Serial4/0/0
 ip address 10.151.100.1 255.255.255.252
 encapsulation ppp
 mpls ip
 serial restart-delay 0
!
router ospf 1
 log-adjacency-changes
 network 10.1.1.151 0.0.0.0 area 0
 network 10.151.100.0 0.0.0.3 area 0
!
mpls ldp router-id Loopback0
```

PE2 Configuration

```
template type pseudowire atom-ipiw
 encapsulation mpls
 interworking ip
!
interface Loopback0
 ip address 10.1.1.152 255.255.255.255
```

```
!
interface FastEthernet0/0/0
 no ip address
 interface pseudowire 100
 source template type pseudowire atom-ipiw
 neighbor 10.1.1.151 123
!
l2vpn xconnect context con1
 member <ac_int>
 member pseudowire1
!
interface Serial4/0/0
 ip address 10.100.152.2 255.255.255.252
 encapsulation ppp
 mpls ip
 serial restart-delay 0
!
router ospf 1
 log-adjacency-changes
 network 10.1.1.152 0.0.0.0 area 0
 network 10.100.152.0 0.0.0.3 area 0
!
mpls ldp router-id Loopback0
```

The **show l2vpn atom binding** command shows that the MTU value for the local and remote routers is 1492 bytes.

PE1

```
Device# show l2vpn atom binding
Destination Address: 10.1.1.152,  VC ID: 123
    Local Label: 105
        Cbit: 1,    VC Type: PPP,    GroupID: 0
        MTU: 1492,   Interface Desc: n/a
        VCCV: CC Type: CW [1], RA [2]
              CV Type: LSPV [2]
    Remote Label: 205
        Cbit: 1,    VC Type: FastEthernet,    GroupID: 0
        MTU: 1492,   Interface Desc: n/a
        VCCV: CC Type: RA [2]
              CV Type: LSPV [2]
Device# show l2vpn atom vc detail
Local interface: Serial2/0/0 up, line protocol up, PPP up
  MPLS VC type is PPP, interworking type is IP
  Destination address: 10.1.1.152, VC ID: 123, VC status: up
    Output interface: Serial4/0/0, imposed label stack {1003 205}
    Preferred path: not configured
    Default path: active
    Next hop: point2point
  Create time: 00:25:29, last status change time: 00:24:54
  Signaling protocol: LDP, peer 10.1.1.152:0 up
    Targeted Hello: 10.1.1.151(LDP Id) -> 10.1.1.152
    Status TLV support (local/remote)   : enabled/supported
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: no fault
      Last local SSS circuit status rcvd: no fault
      Last local SSS circuit status sent: no fault
      Last local  LDP TLV    status sent: no fault
      Last remote LDP TLV    status rcvd: no fault
    MPLS VC labels: local 105, remote 205
    Group ID: local n/a, remote 0
    MTU: local 1492, remote 1492
    Remote interface description:
```

```
  Sequencing: receive disabled, send disabled
  VC statistics:
    packet totals: receive 30, send 29
    byte totals:   receive 2946, send 3364
    packet drops:  receive 0, send 0
```

PE2

```
Device# show l2vpn atom binding
Destination Address: 10.1.1.151,  VC ID: 123
    Local Label: 205
        Cbit: 1,    VC Type: FastEthernet,    GroupID: 0
        MTU: 1492,   Interface Desc: n/a
        VCCV: CC Type: RA [2]
              CV Type: LSPV [2]
    Remote Label: 105
        Cbit: 1,    VC Type: FastEthernet,    GroupID: 0
        MTU: 1492,   Interface Desc: n/a
        VCCV: CC Type: CW [1], RA [2]
              CV Type: LSPV [2]
Device# show l2vpn atom vc detail
Local interface: Fe0/0/0 up, line protocol up, FastEthernet up
  MPLS VC type is FastEthernet, interworking type is IP
  Destination address: 10.1.1.151, VC ID: 123, VC status: up
    Output interface: Se4/0/0, imposed label stack {1002 105}
    Preferred path: not configured
    Default path: active
    Next hop: point2point
  Create time: 00:25:19, last status change time: 00:25:19
  Signaling protocol: LDP, peer 10.1.1.151:0 up
    Targeted Hello: 10.1.1.152(LDP Id) -> 10.1.1.151
    Status TLV support (local/remote)   : enabled/supported
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: no fault
      Last local SSS circuit status rcvd: no fault
      Last local SSS circuit status sent: no fault
      Last local  LDP TLV    status sent: no fault
      Last remote LDP TLV    status rcvd: no fault
    MPLS VC labels: local 205, remote 105
    Group ID: local n/a, remote 0
    MTU: local 1492, remote 1492
    Remote interface description:
  Sequencing: receive disabled, send disabled
  VC statistics:
    packet totals: receive 29, send 30
    byte totals:   receive 2900, send 3426
    packet drops:  receive 0, send 0
```

Examples: Configuring Any Transport over MPLS (AToM) Remote Ethernet Port Shutdown

The following example shows how to enable remote Ethernet port shutdown:

```
configure terminal
!
pseudowire-class eompls
 encapsulation mpls
!
interface GigabitEthernet1/0/0
```

```
 xconnect 10.1.1.1 1 pw-class eompls
  remote link failure notification
```

The following example shows how to disable remote Ethernet port shutdown:

```
configure terminal
!
pseudowire-class eompls
 encapsulation mpls
!
interface GigabitEthernet1/0/0
 xconnect 10.1.1.1 1 pw-class eompls
  no remote link failure notification
```

The related **show** command output reports operational status for all remote L2 Tunnels by interface.

```
Router# show interface G1/0/0
GigabitEthernet1/0/0 is L2 Tunnel remote down, line protocol is up
Hardware is GigMac 4 Port GigabitEthernet, address is 0003.ff4e.12a8 (bia 0003.ff4e.12a8)
  Internet address is 10.9.9.2/16
  MTU 1500 bytes, BW 1000000 Kbit, DLY 10 usec, rely 255/255, load 1/255
Router# show ip interface brief
Interface              IP-Address      OK? Method Status Protocol
GigabitEthernet2/0/0 unassigned      YES NVRAM  L2 Tunnel remote down up
GigabitEthernet2/1/0 unassigned      YES NVRAM  administratively down down
```

Note Remote Ethernet port shutdown is enabled by default when EVC "default encapsulation" is configured.

Examples: Configuring Any Transport over MPLS (AToM) Remote Ethernet Port Shutdown Using Commands Associated with L2VPN Protocol-Based Feature

The following example shows how to enable remote Ethernet port shutdown:

```
configure terminal
!
template type pseudowire eompls
 encapsulation mpls
!
interface GigabitEthernet1/0/0
interface pseudowire 100
 source template type pseudowire eompls
 neighbor 10.1.1.1 1
!
l2vpn xconnect context con1
 remote link failure notification
```

The following example shows how to disable remote Ethernet port shutdown:

```
configure terminal
!
template type pseudowire eompls
 encapsulation mpls
!
interface GigabitEthernet1/0/0
 interface pseudowire 100
 source template type pseudowire eompls
```

```
 neighbor 10.1.1.1 1
!
l2vpn xconnect context con1
 no remote link failure notification
```

The related **show** command output reports operational status for all remote L2 Tunnels by interface.

```
Router# show interface G1/0/0
GigabitEthernet1/0/0 is L2 Tunnel remote down, line protocol is up
Hardware is GigMac 4 Port GigabitEthernet, address is 0003.ff4e.12a8 (bia 0003.ff4e.12a8)
  Internet address is 10.9.9.2/16
  MTU 1500 bytes, BW 1000000 Kbit, DLY 10 usec, rely 255/255, load 1/255
Router# show ip interface brief
Interface              IP-Address      OK? Method Status Protocol
GigabitEthernet2/0/0 unassigned      YES NVRAM  L2 Tunnel remote down up
GigabitEthernet2/1/0 unassigned      YES NVRAM  administratively down down
```

Additional References for Any Transport over MPLS

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
MPLS commands	Cisco IOS Multiprotocol Label Switching Command Reference

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

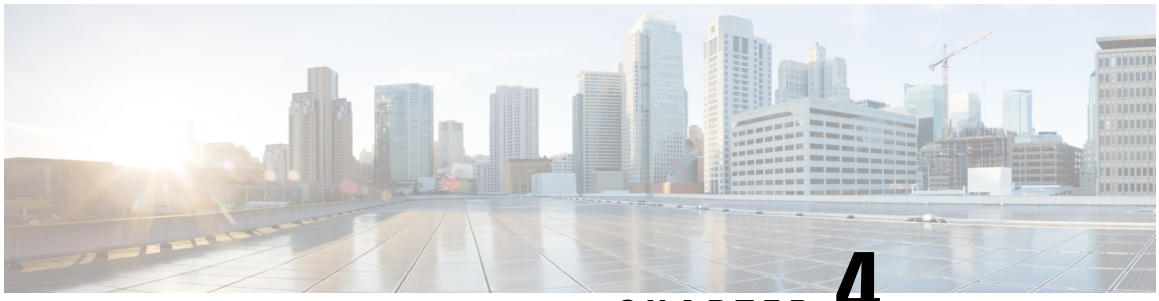
Feature Information for Any Transport over MPLS

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 9: Feature Information for Any Transport over MPLS

Feature Name	Releases	Feature Information
Any Transport over MPLS	Cisco IOS XE Release 3.13.0S	This feature was introduced on the Cisco ASR 920 Routers (ASR-920-12CZ-A, ASR-920-12CZ-D, ASR-920-4SZ-A, ASR-920-4SZ-D).



CHAPTER 4

Loop-Free Alternate Fast Reroute

Loop-Free Alternate (LFA) Fast Reroute (FRR) is a mechanism that provides local protection for unicast traffic in order to rapidly converge traffic flows around link and/or node failures.

Prerequisites for Loop-Free Alternate Fast Reroute

- Any of the following protocols must be supported for Loop-Free Alternate Fast Reroute:
  - Intermediate System-to-Intermediate System (IS-IS)
  - Open Shortest Path First (OSPF)
- While configuring ISIS protocol, **isis network point-to-point** must be configured.

Restrictions for Loop-Free Alternate Fast Reroute

- Logical interfaces namely Port-channel (PoCH) support LFA FRR and remote LFA-FRR, with a single member link. Port-channel can be used as a backup path.
- Micro loops may form due to traffic congestion.
- A Multiprotocol Label Switching (MPLS) traffic engineering (TE) tunnel cannot be used as a protected interface. However, an MPLS-TE tunnel can be a protecting (repair) interface as long as the TE tunnel is used as a primary path.
- For TDM psuedowires, the interfaces supported are CEM (CESoP, SAToP) and IMA (PVC,PVP); supported both on OC-3 and T1/E1 controllers. A maximum of 500 VCs can be configured per OC-3 controller.

- Each bridge domain interface (BDI) protected by FRR can have only one EFP.
- Remote LFA FRR provides better convergence with SFP ports rather than copper ports. As a workaround for copper ports, BFD triggered FRR can be used.
- FRR is *not* supported with POS and serial interfaces.
- Scale limit for FRR-protected global prefixes is 1500 and for layer 3 VPNs, scale limit is 4000.

Information About Loop-Free Alternate Fast Reroute

The Loop-Free Alternate (LFA) Fast Reroute (FRR) feature offers an alternative to the MPLS Traffic Engineering Fast Reroute feature to minimize packet loss due to link or node failure.

LFA FRR enables a backup route to avoid traffic loss if a network fails. The backup routes (repair paths) are precomputed and installed in the router as the backup for the primary paths. After the router detects a link or adjacent node failure, it switches to the backup path to avoid traffic loss.

LFA is a node other than the primary neighbor. Traffic is redirected to an LFA after a network failure. An LFA makes the forwarding decision without any knowledge of the failure. An LFA must neither use a failed element nor use a protecting node to forward traffic. An LFA must not cause loops. By default, LFA is enabled on all supported interfaces as long as the interface can be used as a primary path.

Advantages of using per-prefix LFAs are as follows:

- The repair path forwards traffic during transition when the primary path link is down.
- All destinations having a per-prefix LFA are protected. This leaves only a subset (a node at the far side of the failure) unprotected.

Supported Information

- LFA FRR is supported with equal cost multipath (ECMP).
- Fast Reroute triggered by Bidirectional Forwarding (BFD) is supported.
- Remote LFA tunnels are High Availability aware; hence, Stateful Switchover (SSO) compliant.

Benefits of Loop-Free Alternate Fast Reroute

- Same level of protection from traffic loss
- Simplified configuration
- Link and node protection
- Link and path protection
- LFA (loop-free alternate) paths
- Support for both IP and Label Distribution Protocol (LDP) core
- LFA FRR is supported with equal cost multipath (ECMP).

- Fast Reroute triggered by Bidirectional Forwarding (BFD).
- Remote LFA tunnels are High Availability aware; hence, Stateful Switchover (SSO) compliant.

LFA FRR and Remote LFA FRR over Bridge Domains Interfaces

The router supports bridge domain interfaces (BDI). For information on configuring bridge domains, see Configuring Ethernet Virtual Connections on the Cisco ASR 903 Router.

LFA FRR and remote LFA FRR is supported on bridge domain interfaces on the router. For information on configuring Remote LFA FRR on BDI, see How to Configure Loop-Free Alternate Fast Reroute, on page 83.

IS-IS and IP FRR

When a local link fails in a network, IS-IS recomputes new primary next-hop routes for all affected prefixes. These prefixes are updated in the RIB and the Forwarding Information Base (FIB). Until the primary prefixes are updated in the forwarding plane, traffic directed towards the affected prefixes are discarded. This process can take hundreds of milliseconds.

In IP FRR, IS-IS computes LFA next-hop routes for the forwarding plane to use in case of primary path failures. LFA is computed per prefix.

When there are multiple LFAs for a given primary path, IS-IS uses a tiebreaking rule to pick a single LFA for a primary path. In case of a primary path with multiple LFA paths, prefixes are distributed equally among LFA paths.

Repair Paths

Repair paths forward traffic during a routing transition. When a link or a router fails, due to the loss of a physical layer signal, initially, only the neighboring routers are aware of the failure. All other routers in the network are unaware of the nature and location of this failure until information about this failure is propagated through a routing protocol, which may take several hundred milliseconds. It is, therefore, necessary to arrange for packets affected by the network failure to be steered to their destinations.

A router adjacent to the failed link employs a set of repair paths for packets that would have used the failed link. These repair paths are used from the time the router detects the failure until the routing transition is complete. By the time the routing transition is complete, all routers in the network revise their forwarding data and the failed link is eliminated from the routing computation.

Repair paths are precomputed in anticipation of failures so that they can be activated the moment a failure is detected.

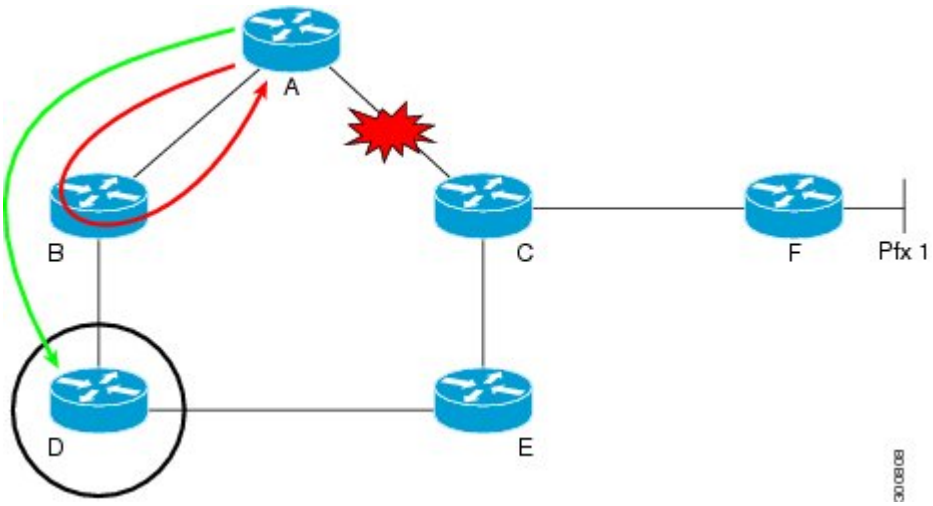
The IPv4 LFA FRR feature uses the following repair paths:

- Equal Cost Multipath (ECMP) uses a link as a member of an equal cost path-split set for a destination. The other members of the set can provide an alternative path when the link fails.
- LFA is a next-hop route that delivers a packet to its destination without looping back. Downstream paths are a subset of LFAs.

Remote LFA FRR

Some topologies (for example the commonly used ring-based topology) require protection that is not afforded by LFA FRR alone. Consider the topology shown in the figure below:

Figure 5: Remote LFA FRR with Ring Topology



The red looping arrow represents traffic that is looping immediately after a failure between node A and C (before network reconvergence). Device A tries to send traffic destined to F to next-hop B. Device B cannot be used as an LFA for prefixes advertised by nodes C and F. The actual LFA is node D. However, node D is not directly connected to the protecting node A. To protect prefixes advertised by C, node A must tunnel the packet around the failed link A-C to node D, provided that the tunnel does not traverse the failing link.

Remote LFA FRR enables you to tunnel a packet around a failed link to a remote loop-free alternate that is more than one hop away. In the figure above, the green arrow between A and D shows the tunnel that is automatically created by the remote LFA feature to bypass looping.

Remote LFA FRR for TDM and ATM Psuedowires

The Router supports two pseudowire types that utilize CEM transport: Structure-Agnostic TDM over Packet (SAToP) and Circuit Emulation Service over Packet-Switched Network (CESoPSN).

-
-
-

Border Gateway Protocol (BGP) Prefix-Independent Convergence (PIC) and LFA FRR Integration

Both the Labeled Border Gateway Protocol (BGP) Prefix-Independent Convergence (PIC) feature and the Loop-Free Alternate (LFA) Fast Reroute (FRR) feature can be configured together on the router.

BGP PIC is supported for bridge domain interfaces (BDI) with FRR.

Note Each bridge domain interface (BDI) protected by FRR can have only one EFP.

For information on configuring BGP PIC, see BGP PIC Edge for IP and MPLS-VPN.

Remote LFA FRR with VPLS

VPLS (Virtual Private LAN Service) enables enterprises to link together their Ethernet-based LANs from multiple sites via the infrastructure provided by their service provider. For information on configuring VPLS, see Configuring Virtual Private LAN Services. Starting With Cisco IOS XE Release 3.10S, Remote LFA FRR is supported with VPLS.

For information on configuring remote LFA FRR with VPLS, see How to Configure Loop-Free Alternate Fast Reroute, on page 83.

How to Configure Loop-Free Alternate Fast Reroute

To enable loop-free alternate fast reroute support for L2VPNs, VPLS, TDM pseudowires and VPWS, you must configure LFA FRR for the routing protocol. You can enable LFA FRR using ISIS or OSFP configurations.

- For information on configuring LFA FRR using OSPF, see OSPFv2 Loop-Free Alternate Fast Reroute in the *IP Routing: OSPF Configuration Guide*.
- For information on configuring Remote LFA FRR using OSPF, seeOSPF IPv4 Remote Loop-Free Alternate IP Fast Reroute in the *IP Routing: OSPF Configuration Guide*.
- For information on configuring Remote LFA FRR using ISIS on the Cisco ASR 903, see Configuring IS-IS Remote Loop-Free Alternate Fast Reroute, on page 83.

Configuring IS-IS Remote Loop-Free Alternate Fast Reroute

The following additional configurations are mandatory:

- **mpls ldp discovery targeted-hello accept**

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router isis** [*area-tag*]
4. **fast-reroute per-prefix** {**level-1** | **level-2**} {**all** | **route-map** *route-map-name*}
5. **fast-reroute remote-lfa** {**level-1** | **level-2**} **mpls-ldp** [**maximum-metric** *metric-value*]
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**router isis** [*area-tag*] **Example:** `Device(config)# router isis ipfrr`	Enables the IS-IS routing protocol and specifies an IS-IS process. • Enters router configuration mode.
Step 4	**fast-reroute per-prefix** {**level-1** | **level-2**} {**all** | **route-map** *route-map-name*} **Example:** `Device (config-router)#  fast-reroute per-prefix level-1 all`	Enables per-prefix FRR. • Configure the **all** keyword to protect all prefixes.
Step 5	**fast-reroute remote-lfa** {**level-1** | **level-2**} **mpls-ldp** [**maximum-metric** *metric-value*] **Example:** `Device(config-router)# fast-reroute remote-lfa level-1 mpls-ldp`	Configures an FRR path that redirects traffic to a remote LFA tunnel for either level 1 or level 2 packets. • Use the **maximum-metric** *metric-value* keyword-argument pair to specify the maximum metric value required to reach the release node.
Step 6	**end** **Example:** `Device(config-router)# end`	Exits router configuration mode and enters privileged EXEC mode.

Recommended Configurations ISIS

For optimal results with remote LFA FRR, it is recommended that you use the following SFP timers:

- ISIS
  - spf-interval 5 50 200
  - prc-interval 5 50 200
  - sp-gen-interval 5 50 200
  - fast-flood 10
- Globally configure the MPLS IGP hold-down timer to avoid an indefinite wait by IGP for synchronization using the **mpls ldp igp sync holdown 2000** command.

Example: Configuring IS-IS Remote Loop-Free Alternate Fast Reroute

The following example shows how to enable remote LFA FRR:

```
Router(config)# router isis
Router(config)# fast-reroute per-prefix level-1 all
Router(config)# fast-reroute per-prefix level-2 all
Router(router-config)# fast-reroute remote-lfa level-1 mpls-ldp
Router(router-config)# fast-reroute remote-lfa level-2 mpls-ldp
```

Example: Configuring Remote LFA FRR with VPLS

Example: Configuration of Remote LFA FRR with Interior Gateway Protocol (IGP)

```
router isis hp
 net 49.0101.0000.0000.0802.00
 is-type level-2-only
 ispf level-2
 metric-style wide
 fast-flood
 set-overload-bit on-startup 180
 max-lsp-lifetime 65535
 lsp-refresh-interval 65000
 spf-interval 5 50 200
 prc-interval 5 50 200
 lsp-gen-interval 5 5 200
 no hello padding
 log-adjacency-changes
 nsf cisco
 fast-reroute per-prefix level-1 all
 fast-reroute per-prefix level-2 all
 fast-reroute remote-lfa level-1 mpls-ldp
 fast-reroute remote-lfa level-2 mpls-ldp
 passive-interface Loopback0
 mpls ldp sync
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-2
```

Example: Configuration of Remote LFA FRR with VPLS at the interface level.

```
!
interface GigabitEthernet0/3/3
 ip address 198.51.100.1 255.255.255.0
 ip router isis hp
 logging event link-status
 load-interval 30
 negotiation auto
 mpls ip
 mpls traffic-eng tunnels
 isis network point-to-point
end
!
```

Example: Configuration of remote LFA FRR with VPLS at the global level.

```
!
l2 vfi Test-2000 manual
 vpn id 2010
 bridge-domain 2010
 neighbor 192.0.2.1 encapsulation mpls
!
```

Example: Configuration of remote LFA FRR with VPLS at Access side.

```
!
interface TenGigabitEthernet0/2/0
 no ip address
 service instance trunk 1 ethernet
  encapsulation dot1q 12-2012
  rewrite ingress tag pop 1 symmetric
  bridge-domain from-encapsulation
 !
```

How to Configure OSPF IPv4 Remote Loop-Free Alternate IP Fast Reroute

Configuring a Remote LFA Tunnel

Perform this task to configure a per-prefix LFA FRR path that redirects traffic to a remote LFA tunnel.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf** *process-id*
4. **fast-reroute per-prefix remote-lfa** [**area** *area-id*] **tunnel mpls-ldp**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**router ospf** *process-id* **Example:** `Device(config)# router ospf 10`	Enables OSPF routing and enters router configuration mode.
Step 4	**fast-reroute per-prefix remote-lfa** [**area** *area-id*] **tunnel mpls-ldp** **Example:** `Device(config-router)# fast-reroute per-prefix remote-lfa area 2 tunnel mpls-ldp`	Configures a per-prefix LFA FRR path that redirects traffic to a remote LFA tunnel via MPLS-LDP. • Use the **area** *area-id* keyword and argument to specify an area in which to enable LFA FRR.

Recommended Configurations OSPF

For optimal results with remote LFA FRR, it is recommended that you use the following SFP timers:

- timers throttle spf 50 200 5000
- timers throttle lsa 50 200 5000
- timers lsa arrival 100
- timers pacing flood 33

Note ISPF should be disabled.

Configuring the Maximum Distance to a Tunnel Endpoint

Perform this task to configure the maximum distance to the tunnel endpoint in a per-prefix LFA FRR path that redirects traffic to a remote LFA tunnel.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router ospf** *process-id*
4. **fast-reroute per-prefix remote-lfa** [**area** *area-id*] **maximum-cost** *distance*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**router ospf** *process-id* **Example:** `Device(config)# router ospf 10`	Enables OSPF routing and enters router configuration mode.
Step 4	**fast-reroute per-prefix remote-lfa** [**area** *area-id*] **maximum-cost** *distance* **Example:**	Configures the maximum distance to the tunnel endpoint in a per-prefix LFA FRR path that redirects traffic to a remote LFA tunnel. • Use the **area** *area-id* keyword and variable to specify an area in which to enable LFA FRR.

	Command or Action	Purpose
	`Device(config-router)# fast-reroute per-prefix remote-lfa area 2 maximum-cost 30`	

Verifying Loop-Free Alternate Fast Reroute

Use one or more of the following commands to verify the LFA FRR configuration

- **show ip cef network-prefix internal**
- **show mpls infrastructure lfd pseudowire internal**
- **show platform hardware pp active feature cef database ipv4 network-prefix**

Example: Verifying LFA FRR with L2VPN

show ip cef internal

The following is sample output from the **show ip cef internal** command:

```
Device# show ip cef 16.16.16.16 internal
16.16.16.16/32, epoch 2, RIB[I], refcount 7, per-destination sharing
  sources: RIB, RR, LTE
  feature space:
   IPRM: 0x00028000
   Broker: linked, distributed at 1st priority
   LFD: 16.16.16.16/32 1 local label
   local label info: global/17
        contains path extension list
        disposition chain 0x3A3C1DF0
        label switch chain 0x3A3C1DF0
  subblocks:
   1 RR source [no flags]
    non-eos chain [16|44]
  ifnums:
   GigabitEthernet0/0/2(9): 7.7.7.2
   GigabitEthernet0/0/7(14): 7.7.17.9
  path 35D61070, path list 3A388FA8, share 1/1, type attached nexthop, for IPv4, flags
has-repair
    MPLS short path extensions: MOI flags = 0x20 label 16
  nexthop 7.7.7.2 GigabitEthernet0/0/2 label [16|44], adjacency IP adj out of
GigabitEthernet0/0/2, addr 7.7.7.2 35E88520
    repair: attached-nexthop 7.7.17.9 GigabitEthernet0/0/7 (35D610E0)
  path 35D610E0, path list 3A388FA8, share 1/1, type attached nexthop, for IPv4, flags
repair, repair-only
  nexthop 7.7.17.9 GigabitEthernet0/0/7, repair, adjacency IP adj out of GigabitEthernet0/0/7,
 addr 7.7.17.9 3A48A4E0
  output chain: label [16|44]
  FRR Primary (0x35D10F60)
  <primary:  TAG adj out of GigabitEthernet0/0/2, addr 7.7.7.2 35E88380>
  <repair:  TAG adj out of GigabitEthernet0/0/7, addr 7.7.17.9 3A48A340>
Rudy17#show mpls infrastructure lfd pseudowire internal
PW ID: 1VC ID: 4, Nexthop address: 16.16.16.16
SSM Class: SSS HW
Segment Count: 1
```

```
VCCV Types Supported:  cw ra ttl
Imposition details:
 Label stack {22 16}, Output interface: Gi0/0/2
 Preferred path: not configured
 Control Word: enabled, Sequencing: disabled
 FIB Non IP entry: 0x35D6CEEC
 Output chain:  AToM Imp (locks 4) label 22 label [16|44]
  FRR Primary (0x35D10F60)
  <primary:  TAG adj out of GigabitEthernet0/0/2, addr 7.7.7.2 35E88380>
Disposition details:
 Local label: 16
 Control Word: enabled, Sequencing: disabled
 SSS Switch: 3976200193
 Output chain:  mpls_eos( connid router-alert AToM Disp (locks 5)/ drop)
```

show mpls infrastructure lfd pseudowire internal

The following is sample output from the **show mpls infrastructure lfd pseudowire internal** command:

```
Device# show mpls infrastructure lfd pseudowire internal
PW ID: 1VC ID: 4, Nexthop address: 16.16.16.16
SSM Class: SSS HW
Segment Count: 1
VCCV Types Supported:  cw ra ttl
Imposition details:
 Label stack {22 16}, Output interface: Gi0/0/2
 Preferred path: not configured
 Control Word: enabled, Sequencing: disabled
 FIB Non IP entry: 0x35D6CEEC
 Output chain:  AToM Imp (locks 4) label 22 label [16|44]
  FRR Primary (0x35D10F60)
  <primary:  TAG adj out of GigabitEthernet0/0/2, addr 7.7.7.2 35E88380>
Disposition details:
 Local label: 16
 Control Word: enabled, Sequencing: disabled
 SSS Switch: 3976200193
 Output chain:  mpls_eos( connid router-alert AToM Disp (locks 5)/ drop)
```

show platform hardware pp active feature cef database

The following is sample output from the **show platform hardware pp active feature cef database** command:

```
Device# show platform hardware pp active feature cef database ipv4 16.16.16.16/32
=== CEF Prefix ===
16.16.16.16/32 -- next hop: UEA Label OCE (PI:0x104abee0, PD:0x10e6b9c8)
                Route Flags: (0)
                Handles (PI:0x104ab6e0) (PD:0x10e68140)

  HW Info:
    TCAM handle: 0x0000023f    TCAM index: 0x0000000d
    FID index  : 0x0000f804    EAID      : 0x0000808a
    MET        : 0x0000400c    FID Count : 0x00000000

=== Label OCE ===
  Label flags: 4
  Num Labels: 1
  Num Bk Labels: 1
  Out Labels: 16
```

```
  Out Backup Labels: 44
  Next OCE Type: Fast ReRoute OCE; Next OCE handle: 0x10e6f428

=== FRR OCE ===
  FRR type         : IP FRR
  FRR state        : Primary
  Primary IF's gid : 3
  Primary FID      : 0x0000f801
  FIFC entries     : 32
  PPO handle       : 0x00000000
  Next OCE         : Adjacency (0x10e63b38)
  Bkup OCE         : Adjacency (0x10e6e590)

=== Adjacency OCE ===
  Adj State: COMPLETE(0)   Address: 7.7.7.2
  Interface: GigabitEthernet0/0/2   Protocol: TAG
  mtu:1500, flags:0x0, fixups:0x0, encap_len:14
  Handles (adj_id:0x00000039) (PI:0x1041d410) (PD:0x10e63b38)
  Rewrite Str: d0:c2:82:17:8a:82:d0:c2:82:17:f2:02:88:47

  HW Info:
    FID index: 0x0000f486    EL3 index: 0x00001003    EL2 index: 0x00000000
    El2RW    : 0x00000107    MET index: 0x0000400c    EAID     : 0x00008060
    HW ADJ FLAGS: 0x40
    Hardware MAC Rewrite Str: d0:c2:82:17:8a:82:08:00:40:00:0d:02

=== Adjacency OCE ===
  Adj State: COMPLETE(0)   Address: 7.7.17.9
  Interface: GigabitEthernet0/0/7   Protocol: TAG
  mtu:1500, flags:0x0, fixups:0x0, encap_len:14
  Handles (adj_id:0x00000012) (PI:0x104acbd0) (PD:0x10e6e590)
  Rewrite Str: d0:c2:82:17:c9:83:d0:c2:82:17:f2:07:88:47

  HW Info:
    FID index: 0x0000f49d    EL3 index: 0x00001008    EL2 index: 0x00000000
    El2RW    : 0x00000111    MET index: 0x00004017    EAID     : 0x0000807d
    HW ADJ FLAGS: 0x40
    Hardware MAC Rewrite Str: d0:c2:82:17:c9:83:08:00:40:00:0d:07
```

Configuration Examples for OSPF IPv4 Remote Loop-Free Alternate IP Fast Reroute

Example: Configuring a Remote LFA Tunnel

The following example shows how to configure a remote per-prefix LFA FRR in area 2. The remote tunnel type is specified as MPLS-LDP:

```
Router(config-router)# fast-reroute per-prefix remote-lfa area 2 tunnel mpls-ldp
```

Example: Configuring the Maximum Distance to a Tunnel Endpoint

The following example shows how to set a maximum cost of 30 in area 2:

```
Router(config-router)# fast-reroute per-prefix remote-lfa area 2 maximum-cost 30
```

Example: Verifying Tunnel Interfaces Created by OSPF IPv4 Remote LFA IPFRR

The following example displays information about about tunnel interfaces created by OSPF IPv4 LFA IPFRR:

```
Router# show ip ospf fast-reroute remote-lfa tunnels

      OSPF Router with ID (192.168.1.1) (Process ID 1)
      Area with ID (0)
      Base Topology (MTID 0)

Interface MPLS-Remote-Lfa3
 Tunnel type: MPLS-LDP
 Tailend router ID: 192.168.3.3
 Termination IP address: 192.168.3.3
 Outgoing interface: Ethernet0/0
 First hop gateway: 192.168.14.4
 Tunnel metric: 20
 Protects:
  192.168.12.2 Ethernet0/1, total metric 30
```

Verifying Remote Loop-Free Alternate Fast Reroute with VPLS

Example: Verifying Remote LFA FRR with VPLS

show ip cef internal

The following is sample output from the **show ip cef internal** command:

```
Router# show ip cef 198.51.100.2/32 internal

198.51.100.2/32, epoch 2, RIB[I], refcount 7, per-destination sharing
  sources: RIB, RR, LTE
  feature space:
   IPRM: 0x00028000
   Broker: linked, distributed at 1st priority
   LFD: 198.51.100.2/32 1 local label
   local label info: global/2033
        contains path extension list
        disposition chain 0x46764E68
        label switch chain 0x46764E68
  subblocks:
   1 RR source [heavily shared]
    non-eos chain [explicit-null|70]
  ifnums:
   TenGigabitEthernet0/1/0(15): 192.0.2.10
   MPLS-Remote-Lfa2(46)
  path 44CE1290, path list 433CF8C0, share 1/1, type attached nexthop, for IPv4, flags
has-repair
    MPLS short path extensions: MOI flags = 0x21 label explicit-null
  nexthop 192.0.2.10 TenGigabitEthernet0/1/0 label [explicit-null|70], adjacency IP adj out
 of TenGigabitEthernet0/1/0, addr 192.0.2.10 404B3960
    repair: attached-nexthop 192.0.2.1 MPLS-Remote-Lfa2 (44CE1300)
  path 44CE1300, path list 433CF8C0, share 1/1, type attached nexthop, for IPv4, flags
repair, repair-only
  nexthop 192.0.2.1 MPLS-Remote-Lfa2, repair, adjacency IP midchain out of MPLS-Remote-Lfa2
 404B3B00
```

```
  output chain: label [explicit-null|70]
  FRR Primary (0x3E25CA00)
  <primary:  TAG adj out of TenGigabitEthernet0/1/0, addr 192.168.101.22 404B3CA0>
  <repair:  TAG midchain out of MPLS-Remote-Lfa2 404B37C0 label 37 TAG adj out of
GigabitEthernet0/3/3, addr 192.0.2.14 461B2F20>
```

show ip cef detail

The following is sample output from the **show ip cef detail** command:

```
Router# show ip cef 198.51.100.2/32 detail

198.51.100.2/32, epoch 2
  local label info: global/2033
  1 RR source [heavily shared]
  nexthop 192.0.2.14 TenGigabitEthernet0/1/0 label [explicit-null|70]
    repair: attached-nexthop 192.0.2.1 MPLS-Remote-Lfa2
  nexthop 192.0.2.1 MPLS-Remote-Lfa2, repair
!
```

show platform hardware pp active feature cef databas

The following is sample output from the **show platform hardware pp active feature cef database** command:

```
Router# show platform hardware pp active feature cef database ipv4 198.51.100.2/32

=== CEF Prefix ===
198.51.100.2/32 -- next hop: UEA Label OCE (PI:0x10936770, PD:0x12dd1cd8)
                Route Flags: (0)
                Handles (PI:0x109099c8) (PD:0x12945968)

  HW Info:
    TCAM handle: 0x00000266    TCAM index: 0x00000015
    FID index  : 0x00008e7f    EAID      : 0x0001d7c4
    MET        : 0x0000401c    FID Count : 0x00000000
=== Label OCE ===
  Label flags: 4
  Num Labels: 1
  Num Bk Labels: 1
  Out Labels: 0
  Out Backup Labels: 70
=== FRR OCE ===
  FRR type         : IP FRR
  FRR state        : Primary
  Primary IF's gid : 52
  Primary FID      : 0x00008cb6
  FIFC entries     : 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0
  PPO handle       : 0x00000000
  Next OCE         : Adjacency (0x130e0df0)
  Bkup OCE         : Adjacency (0x130de608)

=== Adjacency OCE ===
  Adj State: COMPLETE(0)   Address: 192.168.101.22
  Interface: TenGigabitEthernet0/1/0   Protocol: TAG
  mtu:1500, flags:0x0, fixups:0x0, encap_len:14
  Handles (adj_id:0x000016ac) (PI:0x1090cc10) (PD:0x130e0df0)
  Rewrite Str: 18:33:9d:3d:83:10:c8:f9:f9:8d:04:10:88:47
HW Info:
    FID index: 0x00008e7e    EL3 index: 0x00001034    EL2 index: 0x00000000
```

```
    El2RW    : 0x0000010d    MET index: 0x00004012    EAID     : 0x0001d7c1
    HW ADJ FLAGS: 0x40
    Hardware MAC Rewrite Str: 18:33:9d:3d:83:10:08:00:40:00:0d:10
=== Adjacency OCE ===
  Adj State: COMPLETE(0)   Address: 0
  Interface: MPLS-Remote-Lfa2   Protocol: TAG
  mtu:17940, flags:0x40, fixups:0x0, encap_len:0
  Handles (adj_id:0xf80002e8) (PI:0x10da2150) (PD:0x130de608)
  Rewrite Str:

  HW Info:
    FID index: 0x00008ca8    EL3 index: 0x0000101c    EL2 index: 0x00000000
    El2RW    : 0x00000003    MET index: 0x00004024    EAID     : 0x0001d7cb
    HW ADJ FLAGS: 0x40
    Hardware MAC Rewrite Str: 00:00:00:00:00:00:00:00:00:00:00:00

=== Label OCE ===
  Label flags: 4
  Num Labels: 1
Num Bk Labels: 1
  Out Labels: 37
  Out Backup Labels: 37
  Next OCE Type: Adjacency; Next OCE handle: 0x12943a00
=== Adjacency OCE ===
  Adj State: COMPLETE(0)   Address: 30.1.1.1
  Interface: GigabitEthernet0/3/3   Protocol: TAG
  mtu:1500, flags:0x0, fixups:0x0, encap_len:14
  Handles (adj_id:0x0000378e) (PI:0x10909738) (PD:0x12943a00)
  Rewrite Str: c8:f9:f9:8d:01:b3:c8:f9:f9:8d:04:33:88:47

  HW Info:
    FID index: 0x00008c78    EL3 index: 0x0000101c    EL2 index: 0x00000000
    El2RW    : 0x00000109    MET index: 0x0000400e    EAID     : 0x0001cf4b
    HW ADJ FLAGS: 0x40
    Hardware MAC Rewrite Str: c8:f9:f9:8d:01:b3:08:00:40:00:0d:33
```

show mpls l2transport detail

The following is sample output from the **show mpls l2transport detail** command:

```
Router# show mpls l2transport vc 2000 detail

Local interface: VFI Test-1990 vfi up
  Interworking type is Ethernet
  Destination address: 192.0.2.1, VC ID: 2000, VC status: up
    Output interface: Te0/1/0, imposed label stack {0 2217}
    Preferred path: not configured
    Default path: active
    Next hop: 192.51.100.22
  Create time: 1d08h, last status change time: 1d08h
    Last label FSM state change time: 1d08h
  Signaling protocol: LDP, peer 192.0.51.1:0 up
    Targeted Hello: 192.51.100.2(LDP Id) -> 192.51.100.200, LDP is UP
    Graceful restart: configured and enabled
    Non stop routing: not configured and not enabled
    Status TLV support (local/remote)   : enabled/supported
      LDP route watch                   : enabled
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: No fault
      Last BFD dataplane     status rcvd: Not sent
      Last BFD peer monitor  status rcvd: No fault
```

```
Last local AC  circuit status rcvd: No fault
Last local AC  circuit status sent: No fault
Last local PW i/f circ status rcvd: No fault
Last local LDP TLV     status sent: No fault
Last remote LDP TLV    status rcvd: No fault
```

Verifying Tunnel Interfaces Created by OSPF IPv4 Remote LFA IPFRR

SUMMARY STEPS

1. **enable**
2. **show ip ospf fast-reroute remote-lfa tunnels**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show ip ospf fast-reroute remote-lfa tunnels** **Example:** `Device# show ip ospf fast-reroute remote-lfa tunnels`	Displays information about the OSPF per-prefix LFA FRR configuration.

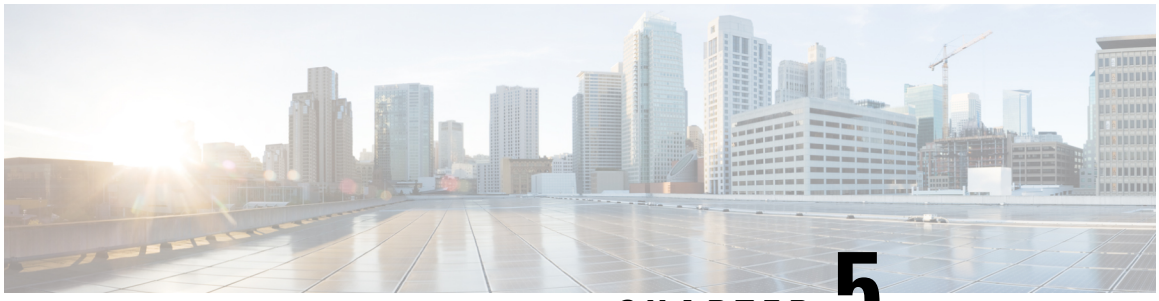
Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
MPLS commands	Multiprotocol Label Switching Command Reference

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html



CHAPTER 5

Configuring Virtual Private LAN Services

Virtual Private LAN Services (VPLS) enables enterprises to link together their Ethernet-based LANs from multiple sites via the infrastructure provided by their service provider.

This module explains VPLS and how to configure it.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for Virtual Private LAN Services

Before you configure Virtual Private LAN Services (VPLS), ensure that the network is configured as follows:

- Configure IP routing in the core so that provider edge (PE) devices can reach each other via IP.
- Configure Multiprotocol Label Switching (MPLS) in the core so that a label switched path (LSP) exists between PE devices.
- Configure a loopback interface for originating and terminating Layer 2 traffic. Ensure that PE devices can access the loopback interface of the other device. Note that the loopback interface is not required in all cases. For example, tunnel selection does not need a loopback interface when VPLS is directly mapped to a traffic engineering (TE) tunnel.

- Identify peer PE devices and attach Layer 2 circuits to VPLS at each PE device.

Restrictions for Virtual Private LAN Services

The following general restrictions apply to all transport types under Virtual Private LAN Services (VPLS):

- If you do not enable the EFP feature template, then there is no traffic flow between EFP and VFI (when EFP is with Split Horizon group and VFI is default). But when you enable the EFP feature template, then there is traffic flow between EFP and VFI because of design limitations.
- Supported maximum values:
  - Total number of virtual forwarding instances (VFIs): 4096 (4 K)
- Software-based data plane is not supported.
- The Border Gateway Protocol (BGP) autodiscovery process does not support dynamic, hierarchical VPLS.
- Load sharing and failover on redundant customer-edge-provider-edge (CE-PE) links are not supported.
- Point to Multipoint (P2MP) Resource Reservation Protocol (RSVP) for MPLS Traffic Engineering (MPLS-TE) is not supported over VPLS on the Cisco RSP2 and RSP3 routers.
- Traffic drops are observed for lower sized MPLS pseudowire packets.

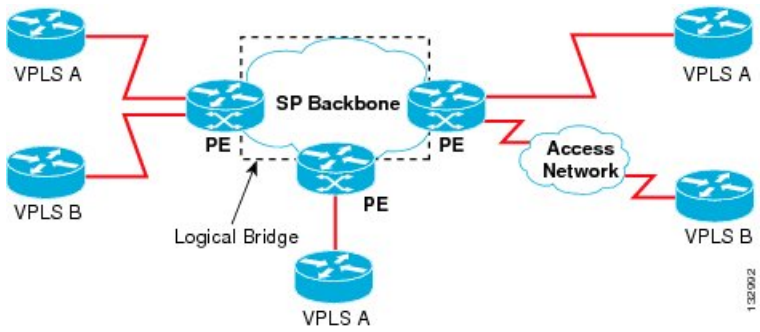
Information About Virtual Private LAN Services

VPLS Overview

Virtual Private LAN Services (VPLS) enables enterprises to link together their Ethernet-based LANs from multiple sites via the infrastructure provided by their service provider. From the enterprise perspective, the service provider's public network looks like one giant Ethernet LAN. For the service provider, VPLS provides an opportunity to deploy another revenue-generating service on top of the existing network without major capital expenditures. Operators can extend the operational life of equipment in their network.

VPLS uses the provider core to join multiple attachment circuits together to simulate a virtual bridge that connects the multiple attachment circuits together. From a customer point of view, there is no topology for VPLS. All customer edge (CE) devices appear to connect to a logical bridge emulated by the provider core (see the figure below).

Figure 6: VPLS Topology



Full-Mesh Configuration

A full-mesh configuration requires a full mesh of tunnel label switched paths (LSPs) between all provider edge (PE) devices that participate in Virtual Private LAN Services (VPLS). With a full mesh, signaling overhead and packet replication requirements for each provisioned virtual circuit (VC) on a PE can be high.

You set up a VPLS by first creating a virtual forwarding instance (VFI) on each participating PE device. The VFI specifies the VPN ID of a VPLS domain, the addresses of other PE devices in the domain, and the type of tunnel signaling and encapsulation mechanism for each peer PE device.

The set of VFIs formed by the interconnection of the emulated VCs is called a VPLS instance; it is the VPLS instance that forms the logic bridge over a packet switched network. After the VFI has been defined, it needs to be bound to an attachment circuit to the CE device. The VPLS instance is assigned a unique VPN ID.

PE devices use the VFI to establish a full-mesh LSP of emulated VCs to all other PE devices in the VPLS instance. PE devices obtain the membership of a VPLS instance through static configuration using the Cisco IOS CLI.

A full-mesh configuration allows the PE device to maintain a single broadcast domain. When the PE device receives a broadcast, multicast, or unknown unicast packet on an attachment circuit (AC), it sends the packet out on all other ACs and emulated circuits to all other CE devices participating in that VPLS instance. The CE devices see the VPLS instance as an emulated LAN.

To avoid the problem of a packet looping in the provider core, PE devices enforce a “split-horizon” principle for emulated VCs. In a split horizon, if a packet is received on an emulated VC, it is not forwarded on any other emulated VC.

The packet forwarding decision is made by looking up the Layer 2 VFI of a particular VPLS domain.

A VPLS instance on a particular PE device receives Ethernet frames that enter on specific physical or logical ports and populates a MAC table similarly to how an Ethernet switch works. The PE device can use the MAC address to switch these frames into the appropriate LSP for delivery to the another PE device at a remote site.

If the MAC address is not available in the MAC address table, the PE device replicates the Ethernet frame and floods it to all logical ports associated with that VPLS instance, except the ingress port from which it just entered. The PE device updates the MAC table as it receives packets on specific ports and removes addresses not used for specific periods.

Static VPLS Configuration

Virtual Private LAN Services (VPLS) over Multiprotocol Label Switching-Transport Profile (MPLS-TP) tunnels allows you to deploy a multipoint-to-multipoint layer 2 operating environment over an MPLS-TP network for services such as Ethernet connectivity and multicast video. To configure static VPLS, you must specify a static range of MPLS labels using the **mpls label range** command with the **static** keyword.

H-VPLS

Hierarchical VPLS (H-VPLS) reduces signaling and replication overhead by using full-mesh and hub-and-spoke configurations. Hub-and-spoke configurations operate with split horizon to allow packets to be switched between pseudowires (PWs), effectively reducing the number of PWs between provider edge (PE) devices.

Note Split horizon is the default configuration to avoid broadcast packet looping.

Supported Features

Multipoint-to-Multipoint Support

In a multipoint-to-multipoint network, two or more devices are associated over the core network. No single device is designated as the Root node; all devices are considered as Root nodes. All frames can be exchanged directly between the nodes.

Non-Transparent Operation

A virtual Ethernet connection (VEC) can be transparent or non-transparent with respect to Ethernet protocol data units (PDUs). The VEC non-transparency allows users to have a Frame Relay-type service between Layer 3 devices.

Circuit Multiplexing

Circuit multiplexing allows a node to participate in multiple services over a single Ethernet connection. By participating in multiple services, the Ethernet connection is attached to multiple logical networks. Some examples of possible service offerings are VPN services between sites, Internet services, and third-party connectivity for intercompany communications.

MAC-Address Learning, Forwarding, and Aging

Provider edge (PE) devices must learn remote MAC addresses and directly attached MAC addresses on ports that face the external network. MAC address learning accomplishes this by deriving the topology and forwarding information from packets originating at customer sites. A timer is associated with stored MAC addresses. After the timer expires, the entry is removed from the table.

Jumbo Frame Support

Jumbo frame support provides support for frame sizes between 1548 and 9216 bytes. You use the CLI to establish the jumbo frame size for any value specified in the above range. The default value is 1500 bytes in any Layer 2/VLAN interface. You can configure jumbo frame support on a per-interface basis.

Q-in-Q Support and Q-in-Q to EoMPLS VPLS Support

With 802.1Q tunneling (Q-in-Q), the customer edge (CE) device issues VLAN-tagged packets and VPLS forwards these packets to a far-end CE device. Q-in-Q refers to the fact that one or more 802.1Q tags may be located in a packet within the interior of the network. As packets are received from a CE device, an additional VLAN tag is added to incoming Ethernet packets to segregate traffic from different CE devices. Untagged packets originating from a CE device use a single tag within the interior of the VLAN switched network, whereas previously tagged packets originating from the CE device use two or more tags.

VPLS Services

Transparent LAN Service

Transparent LAN Service (TLS) is an extension to the point-to-point port-based Ethernet over Multiprotocol Label Switching (EoMPLS), which provides bridging protocol transparency (for example, bridge protocol data units [BPDUs]) and VLAN values. Bridges see this service as an Ethernet segment. With TLS, the PE device forwards all Ethernet packets received from the customer-facing interface (including tagged and untagged packets, and BPDUs) as follows:

- To a local Ethernet interface or an emulated virtual circuit (VC) if the destination MAC address is found in the Layer 2 forwarding table.
- To all other local Ethernet interfaces and emulated VCs belonging to the same VPLS domain if the destination MAC address is a multicast or broadcast address or if the destination MAC address is not found in the Layer 2 forwarding table.

Note You must enable Layer 2 protocol tunneling to run the Cisco Discovery Protocol (CDP), the VLAN Trunking Protocol (VTP), and the Spanning-Tree Protocol (STP).

Ethernet Virtual Connection Service

Ethernet Virtual Connection Service (EVCS) is an extension to the point-to-point VLAN-based Ethernet over MPLS (EoMPLS) that allows devices to reach multiple intranet and extranet locations from a single physical port. With EVCS, the provider edge (PE) device forwards all Ethernet packets with a particular VLAN tag received from the customer-facing interface (excluding bridge protocol data units [BPDUs]) as follows:

- To a local Ethernet interface or to an emulated virtual circuit (VC) if the destination MAC address is found in the Layer 2 forwarding table.
- To all other local Ethernet interfaces and emulated VCs belonging to the same Virtual Private LAN Services (VPLS) domain if the destination MAC address is a multicast or a broadcast address or if the destination MAC address is not found in the Layer 2 forwarding table.

Note Because it has only local significance, the demultiplexing VLAN tag that identifies a VPLS domain is removed before the packet is forwarded to the outgoing Ethernet interfaces or emulated VCs.

How to Configure Virtual Private LAN Services

Provisioning a Virtual Private LAN Services (VPLS) link involves provisioning the associated attachment circuit and a virtual forwarding instance (VFI) on a provider edge (PE) device.

In Cisco IOS XE Release 3.7S, the L2VPN Protocol-Based CLIs feature was introduced. This feature provides a set of processes and an improved infrastructure for developing and delivering Cisco IOS software on various Cisco platforms. This feature introduces new commands and modifies or replaces existing commands to achieve a consistent functionality across Cisco platforms and provide cross-Operating System (OS) support.

This section consists of tasks that use the commands existing prior to Cisco IOS XE Release 3.7S and a corresponding task that uses the commands introduced or modified by the L2VPN Protocol-Based CLIs feature.

Configuring PE Layer 2 Interfaces on CE Devices

You can configure the Ethernet flow point (EFP) as a Layer 2 virtual interface. You can also select tagged or untagged traffic from a customer edge (CE) device.

Configuring 802.1Q Access Ports for Tagged Traffic from a CE Device

Note When Ethernet Virtual Connection Service (EVCS) is configured, a provider edge (PE) device forwards all Ethernet packets with a particular VLAN tag to a local Ethernet interface or emulated virtual circuit (VC) if the destination MAC address is found in the Layer 2 forwarding table.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **no ip address** [*ip-address mask*] [**secondary**]
5. **negotiation auto**
6. **service instance** *si-id* **ethernet**
7. **encapsulation dot1q** *vlan-id*
8. **bridge-domain** *bd-id*
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Device(config)# interface gigabitethernet 0/0/1`	Specifies an interface and enters interface configuration mode.
Step 4	**no ip address** [*ip-address mask*] [**secondary**] **Example:** `Device(config-if)# no ip address`	Disables IP processing.
Step 5	**negotiation auto** **Example:** `Device(config-if)# negotiation auto`	Enables the autonegotiation protocol to configure the speed, duplex, and automatic flow control of the Gigabit Ethernet interface.
Step 6	**service instance** *si-id* **ethernet** **Example:** `Device(config-if)# service instance 10 ethernet`	Specifies the service instance ID and enters service instance configuration mode.
Step 7	**encapsulation dot1q** *vlan-id* **Example:** `Device(config-if-srv)# encapsulation dot1q 200`	Defines the matching criteria to map 802.1Q frames ingress on an interface to the appropriate service instance. Ensure that the interface on the adjoining customer edge (CE) device is on the same VLAN as this PE device.
Step 8	**bridge-domain** *bd-id* **Example:** `Device(config-if-srv)# bridge-domain 100`	Binds a service instance to a bridge domain instance.
Step 9	**end** **Example:** `Device(config-if-srv)# end`	Exits service instance configuration mode and returns to privileged EXEC mode.

Configuring 802.1Q Access Ports for Tagged Traffic from a CE Device: Alternate Configuration

Note When Ethernet Virtual Connection Service (EVCS) is configured, the PE device forwards all Ethernet packets with a particular VLAN tag to a local Ethernet interface or an emulated virtual circuit (VC) if the destination MAC address is found in the Layer 2 forwarding table.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **no ip address** [*ip-address mask*] [**secondary**]
5. **negotiation auto**
6. **service instance** *si-id* **ethernet**
7. **encapsulation dot1q** *vlan-id*
8. **exit**
9. **exit**
10. **bridge-domain** *bd-id*
11. **member** *interface-type-number* **service-instance** *service-id* [**split-horizon group** *group-id*]
12. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Device(config)# interface gigabitethernet 0/0/1`	Specifies an interface and enters interface configuration mode.
Step 4	**no ip address** [*ip-address mask*] [**secondary**] **Example:** `Device(config-if)# no ip address`	Disables IP processing.
Step 5	**negotiation auto** **Example:** `Device(config-if)# negotiation auto`	Enables the autonegotiation protocol to configure the speed, duplex, and automatic flow control of the Gigabit Ethernet interface.
Step 6	**service instance** *si-id* **ethernet** **Example:** `Device(config-if)# service instance 10 ethernet`	Specifies a service instance ID and enters service instance configuration mode.

	Command or Action	Purpose
Step 7	**encapsulation dot1q** *vlan-id* **Example:** `Device(config-if-srv)# encapsulation dot1q 200`	Defines the matching criteria to map 802.1Q frames ingress on an interface to the appropriate service instance. • Ensure that the interface on the adjoining customer edge (CE) device is on the same VLAN as this provider edge (PE) device.
Step 8	**exit** **Example:** `Device(config-if-srv)# exit`	Exits service instance configuration mode and returns to interface configuration mode.
Step 9	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.
Step 10	**bridge-domain** *bd-id* **Example:** `Device(config)# bridge-domain 100`	Specifies the bridge domain ID and enters bridge-domain configuration mode.
Step 11	**member** *interface-type-number* **service-instance** *service-id* [**split-horizon group** *group-id*] **Example:** `Device(config-bdomain)# member gigabitethernet0/0/1 service-instance 1000`	Binds a service instance to a bridge domain instance.
Step 12	**end** **Example:** `Device(config-bdomain)# end`	Exits bridge-domain configuration mode and returns to privileged EXEC mode.

Configuring Access Ports for Untagged Traffic from a CE Device

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **no ip address** [*ip-address mask*] [**secondary**]
5. **negotiation auto**
6. **service instance** *si-id* **ethernet**
7. **encapsulation untagged**
8. **bridge-domain** *bd-id*
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Device(config)# interface gigabitethernet 0/0/0`	Specifies an interface and enters interface configuration mode.
Step 4	**no ip address** [*ip-address mask*] [**secondary**] **Example:** `Device(config-if)# no ip address`	Disables IP processing.
Step 5	**negotiation auto** **Example:** `Device(config-if)# negotiation auto`	Enables the autonegotiation protocol to configure the speed, duplex, and automatic flow control of the Gigabit Ethernet interface.
Step 6	**service instance** *si-id* **ethernet** **Example:** `Device(config-if)# service instance 10 ethernet`	Specifies a service instance ID and enters service instance configuration mode.
Step 7	**encapsulation untagged** **Example:** `Device(config-if-srv)# encapsulation untagged`	Defines the matching criteria to map untagged ingress Ethernet frames on an interface to the appropriate service instance. • Ensure that the interface on the adjoining customer edge (CE) device is on the same VLAN as this provider edge (PE) device.
Step 8	**bridge-domain** *bd-id* **Example:** `Device(config-if-srv)# bridge-domain 100`	Binds a service instance or MAC tunnel to a bridge domain instance.
Step 9	**end** **Example:**	Exits service instance configuration mode and returns to privileged EXEC mode.

	Command or Action	Purpose
	`Device(config-if-srv)# end`	

Configuring Access Ports for Untagged Traffic from a CE Device: Alternate Configuration

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **no ip address** [*ip-address mask*] [**secondary**]
5. **negotiation auto**
6. **service instance** *si-id* **ethernet**
7. **encapsulation untagged**
8. **exit**
9. **exit**
10. **bridge-domain** *bd-id*
11. **member** *interface-type-number* **service-instance** *service-id* [**split-horizon group** *group-id*]
12. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Device(config)# interface gigabitethernet 0/4/4`	Specifies an interface and enters interface configuration mode.
Step 4	**no ip address** [*ip-address mask*] [**secondary**] **Example:** `Device(config-if)# no ip address`	Disables IP processing.

	Command or Action	Purpose
Step 5	**negotiation auto** **Example:** `Device(config-if)# negotiation auto`	Enables the autonegotiation protocol to configure the speed, duplex, and automatic flow control of the Gigabit Ethernet interface.
Step 6	**service instance** *si-id* **ethernet** **Example:** `Device(config-if)# service instance 10 ethernet`	Specifies a service instance ID and enters service instance configuration mode.
Step 7	**encapsulation untagged** **Example:** `Device(config-if-srv)# encapsulation untagged`	Defines the matching criteria to map untagged ingress Ethernet frames on an interface to the appropriate service instance. • Ensure that the interface on the adjoining customer edge (CE) device is on the same VLAN as this provider edge (PE) device.
Step 8	**exit** **Example:** `Device(config-if-srv)# exit`	Exits service instance configuration mode and returns to interface configuration mode.
Step 9	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.
Step 10	**bridge-domain** *bd-id* **Example:** `Device(config)# bridge-domain 100`	Specifies the bridge domain ID and enters bridge-domain configuration mode.
Step 11	**member** *interface-type-number* **service-instance** *service-id* [**split-horizon group** *group-id*] **Example:** `Device(config-bdomain)# member gigabitethernet0/4/4 service-instance 1000`	Binds a service instance to a bridge domain instance.
Step 12	**end** **Example:** `Device(config-bdomain)# end`	Exits bridge-domain configuration mode and returns to privileged EXEC mode.

Configuring Q-in-Q EFP

Note When a thread-local storage (TLS) is configured, the provider edge (PE) device forwards all Ethernet packets received from the customer edge (CE) device to all local Ethernet interfaces and emulated virtual circuits (VCs) that belong to the same Virtual Private LAN Services (VPLS) domain if the MAC address is not found in the Layer 2 forwarding table.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **no ip address** [*ip-address mask*] [**secondary**]
5. **negotiation auto**
6. **service instance** *si-id* **ethernet**
7. **encapsulation dot1q** *vlan-id* **second-dot1q** *vlan-id*
8. **bridge-domain** *bd-id*
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Device(config)# interface gigabitethernet 0/0/2`	Specifies an interface and enters interface configuration mode.
Step 4	**no ip address** [*ip-address mask*] [**secondary**] **Example:** `Device(config-if)# no ip address`	Disables IP processing.
Step 5	**negotiation auto** **Example:** `Device(config-if)# negotiation auto`	Enables the autonegotiation protocol to configure the speed, duplex, and automatic flow control of the Gigabit Ethernet interface.

	Command or Action	Purpose
Step 6	**service instance** *si-id* **ethernet** **Example:** `Device(config-if)# service instance 10 ethernet`	Specifies a service instance ID and enters service instance configuration mode.
Step 7	**encapsulation dot1q** *vlan-id* **second-dot1q** *vlan-id* **Example:** `Device(config-if-srv)# encapsulation dot1q 200 second-dot1q 400`	Defines the matching criteria to map Q-in-Q ingress frames on an interface to the appropriate service instance. • Ensure that the interface on the adjoining CE device is on the same VLAN as this PE device.
Step 8	**bridge-domain** *bd-id* **Example:** `Device(config-if-srv)# bridge-domain 100`	Binds a service instance or a MAC tunnel to a bridge domain instance.
Step 9	**end** **Example:** `Device(config-if-srv)# end`	Exits service instance configuration mode and returns to privileged EXEC mode.

Configuring Q-in-Q EFP: Alternate Configuration

Note When a thread-local storage (TLS) is configured, the provider edge (PE) device forwards all Ethernet packets received from the customer edge (CE) device to all local Ethernet interfaces and emulated virtual circuits (VCs) belonging to the same Virtual Private LAN Services (VPLS) domain if the MAC address is not found in the Layer 2 forwarding table.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **no ip address** [*ip-address mask*] [**secondary**]
5. **negotiation auto**
6. **service instance** *si-id* **ethernet**
7. **encapsulation dot1q** *vlan-id* **second-dot1q** *vlan-id*
8. **exit**
9. **exit**
10. **bridge-domain** *bd-id*
11. **member** *interface-type-number* **service-instance** *service-id* [**split-horizon group** *group-id*]
12. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Device(config)# interface gigabitethernet 0/0/2`	Specifies an interface and enters interface configuration mode.
Step 4	**no ip address** [*ip-address mask*] [**secondary**] **Example:** `Device(config-if)# no ip address`	Disables IP processing.
Step 5	**negotiation auto** **Example:** `Device(config-if)# negotiation auto`	Enables the autonegotiation protocol to configure the speed, duplex, and automatic flow control of the Gigabit Ethernet interface.
Step 6	**service instance** *si-id* **ethernet** **Example:** `Device(config-if)# service instance 10 ethernet`	Specifies a service instance ID and enters service instance configuration mode.
Step 7	**encapsulation dot1q** *vlan-id* **second-dot1q** *vlan-id* **Example:** `Device(config-if-srv)# encapsulation dot1q 200 second-dot1q 400`	Defines the matching criteria to map Q-in-Q ingress frames on an interface to the appropriate service instance. • Ensure that the interface on the adjoining CE device is on the same VLAN as this PE device.
Step 8	**exit** **Example:** `Device(config-if-srv)# exit`	Exits service instance configuration mode and returns to interface configuration mode.
Step 9	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.

	Command or Action	Purpose
Step 10	**bridge-domain** *bd-id* **Example:** `Device(config)# bridge-domain 100`	Specifies the bridge domain ID and enters bridge-domain configuration mode.
Step 11	**member** *interface-type-number* **service-instance** *service-id* [**split-horizon group** *group-id*] **Example:** `Device(config-bdomain)# member gigabitethernet0/0/2 service-instance 1000`	Binds a service instance to a bridge domain instance.
Step 12	**end** **Example:** `Device(config-bdomain)# end`	Exits bridge-domain configuration mode and returns to privileged EXEC mode.

Configuring MPLS on a PE Device

To configure Multiprotocol Label Switching (MPLS) on a provider edge (PE) device, configure the required MPLS parameters.

Note Before configuring MPLS, ensure that IP connectivity exists between all PE devices by configuring Interior Gateway Protocol (IGP), Open Shortest Path First (OSPF), or Intermediate System to Intermediate System (IS-IS) between PE devices.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls label protocol** {**ldp** | **tdp**}
4. **mpls ldp logging neighbor-changes**
5. **mpls ldp discovery hello holdtime** *seconds*
6. **mpls ldp router-id** *interface-type-number* [**force**]
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**mpls label protocol** {**ldp** | **tdp**} **Example:** `Device(config)# mpls label protocol ldp`	Specifies the label distribution protocol for the platform.
Step 4	**mpls ldp logging neighbor-changes** **Example:** `Device(config)# mpls ldp logging neighbor-changes`	(Optional) Generates system error logging (syslog) messages when LDP sessions go down.
Step 5	**mpls ldp discovery hello holdtime** *seconds* **Example:** `Device(config)# mpls ldp discovery hello holdtime 5`	Configures the interval between the transmission of consecutive LDP discovery hello messages or the hold time for an LDP transport connection.
Step 6	**mpls ldp router-id** *interface-type-number* [**force**] **Example:** `Device(config)# mpls ldp router-id loopback0 force`	Specifies a preferred interface for the LDP router ID.
Step 7	**end** **Example:** `Device(config)# end`	Exits global configuration mode and returns to privileged EXEC mode.

Configuring a VFI on a PE Device

The virtual forwarding interface (VFI) specifies the VPN ID of a Virtual Private LAN Services (VPLS) domain, the addresses of other provider edge (PE) devices in the domain, and the type of tunnel signaling and encapsulation mechanism for each peer.

Note Only Multiprotocol Label Switching (MPLS) encapsulation is supported.

Note You must configure BDI on the bridge domain that has the association with the VFI.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **l2 vfi** *name* **manual**
4. **vpn id** *vpn-id*
5. **neighbor** *remote-router-id vc-id* {**encapsulation** *encapsulation-type* | **pw-class** *pw-name*} [**no-split-horizon**]
6. **bridge-domain** *bd-id*
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**l2 vfi** *name* **manual** **Example:** `Device(config)# l2 vfi vfi110 manual`	Establishes a Layer 2 VPN (L2VPN) virtual forwarding interface (VFI) between two or more separate networks and enters VFI configuration mode.
Step 4	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 110`	Configures a VPN ID for a VPLS domain. • The emulated VCs bound to this Layer 2 virtual routing and forwarding (VRF) instance use this VPN ID for signaling.
Step 5	**neighbor** *remote-router-id vc-id* {**encapsulation** *encapsulation-type*	**pw-class** *pw-name*} [**no-split-horizon**] **Example:** `Device(config-vfi)# neighbor 172.16.10.2 4 encapsulation mpls`	Specifies the type of tunnel signaling and encapsulation mechanism for each VPLS peer. **Note** Split horizon is the default configuration to avoid broadcast packet looping and to isolate Layer 2 traffic. Use the **no-split-horizon** keyword to disable split horizon and to configure multiple VCs per spoke into the same VFI.
Step 6	**bridge-domain** *bd-id* **Example:** `Device(config-vfi)# bridge-domain 100`	Specifies a bridge domain.

	Command or Action	Purpose
Step 7	**end** **Example:** `Device(config-vfi)# end`	Exits VFI configuration mode and returns to privileged EXEC mode.

Configuring a VFI on a PE Device: Alternate Configuration

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **l2vpn vfi context** *name*
4. **vpn id** *id*
5. **member** *ip-address* [*vc-id*] **encapsulation mpls**
6. **exit**
7. **bridge-domain** *bd-id*
8. **member vfi** *vfi-name*
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**l2vpn vfi context** *name* **Example:** `Device(config)# l2vpn vfi context vfi110`	Establishes a L2VPN VFI between two or more separate networks, and enters VFI configuration mode.
Step 4	**vpn id** *id* **Example:** `Device(config-vfi)# vpn id 110`	Configures a VPN ID for a Virtual Private LAN Services (VPLS) domain. The emulated virtual circuits (VCs) bound to this Layer 2 virtual routing and forwarding (VRF) instance use this VPN ID for signaling.
Step 5	**member** *ip-address* [*vc-id*] **encapsulation mpls** **Example:**	Specifies the devices that form a point-to-point Layer 2 VPN (L2VPN) virtual forwarding interface (VFI)

	Command or Action	Purpose
	`Device(config-vfi)# member 172.16.10.2 4 encapsulation mpls`	connection and Multiprotocol Label Switching (MPLS) as the encapsulation type.
Step 6	**exit** **Example:** `Device(config-vfi)# exit`	Exits VFI configuration mode and returns to global configuration mode.
Step 7	**bridge-domain** *bd-id* **Example:** `Device(config)# bridge-domain 100`	Specifies a bridge domain and enters bridge-domain configuration mode.
Step 8	**member vfi** *vfi-name* **Example:** `Device(config-bdomain)# member vfi vfi110`	Binds a VFI instance to a bridge domain instance.
Step 9	**end** **Example:** `Device(config-bdomain)# end`	Exits bridge-domain configuration mode and returns to privileged EXEC mode.

Configuring Static Virtual Private LAN Services

To configure static Virtual Private LAN Services (VPLS), perform the following tasks:

- Configuring a Pseudowire for Static VPLS
- Configuring VFI for Static VPLS
- Configuring a VFI for Static VPLS: Alternate Configuration
- Configuring an Attachment Circuit for Static VPLS
- Configuring an Attachment Circuit for Static VPLS: Alternate Configuration
- Configuring an MPLS-TP Tunnel for Static VPLS with TP
- Configuring a VFI for Static VPLS: Alternate Configuration

Configuring a Pseudowire for Static VPLS

The configuration of pseudowires between provider edge (PE) devices helps in the successful transmission of the Layer 2 frames between PE devices.

Use the pseudowire template to configure the virtual circuit (VC) type for the virtual path identifier (VPI) pseudowire. In the following task, the pseudowire will go through a Multiprotocol Label Switching (MPLS)-Tunneling Protocol (TP) tunnel.

The pseudowire template configuration specifies the characteristics of the tunneling mechanism that is used by the pseudowires, which are:

- Encapsulation type
- Control protocol
- Payload-specific options
- Preferred path

Perform this task to configure a pseudowire template for static Virtual Private LAN Services (VPLS).

Note Ensure that you perform this task before configuring the virtual forwarding instance (VFI) peer. If the VFI peer is configured before the pseudowire class, the configuration is incomplete until the pseudowire class is configured. The **show running-config** command displays an error stating that configuration is incomplete.

```
Device# show running-config | sec vfi

l2 vfi config manual
 vpn id 1000
 ! Incomplete point-to-multipoint vfi config
```

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **template type pseudowire** *name*
4. **encapsulation mpls**
5. **signaling protocol none**
6. **preferred-path interface Tunnel-tp** *interface-number*
7. **exit**
8. **interface pseudowire** *number*
9. **source template type pseudowire** *name*
10. **neighbor** *peer-address vcid-value*
11. **label** *local-pseudowire-label remote-pseudowire-label*
12. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Device# configure terminal`	
Step 3	**template type pseudowire** *name* **Example:** `Device(config)# template type pseudowire static-vpls`	Specifies the template type as pseudowire and enters template configuration mode.
Step 4	**encapsulation mpls** **Example:** `Device(config-template)# encapsulation mpls`	Specifies the tunneling encapsulation. • For Any Transport over MPLS (AToM), the encapsulation type is MPLS.
Step 5	**signaling protocol none** **Example:** `Device(config-template)# signaling protocol none`	Specifies that no signaling protocol is configured for the pseudowire class.
Step 6	**preferred-path interface Tunnel-tp** *interface-number* **Example:** `Device(config-template)# preferred-path interface Tunnel-tp 1`	(Optional) Specifies the path that traffic uses: an MPLS Traffic Engineering (TE) tunnel or destination IP address and Domain Name Server (DNS) name.
Step 7	**exit** **Example:** `Device(config-template)# exit`	Exits template configuration mode and returns to global configuration mode.
Step 8	**interface pseudowire** *number* **Example:** `Device(config)# interface pseudowire 1`	Establishes a pseudowire interface and enters interface configuration mode.
Step 9	**source template type pseudowire** *name* **Example:** `Device(config-if)# source template type pseudowire static-vpls`	Configures the source template type of the configured pseudowire.
Step 10	**neighbor** *peer-address vcid-value* **Example:** `Device(config-if)# neighbor 10.0.0.1 123`	Specifies the peer IP address and VC ID value of a Layer 2 VPN (L2VPN) pseudowire.

	Command or Action	Purpose
Step 11	**label** *local-pseudowire-label remote-pseudowire-label* **Example:** `Device(config-if)# label 301 17`	Configures an Any Transport over MPLS (AToM) static pseudowire connection by defining local and remote circuit labels.
Step 12	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configuring VFI for Static VPLS

Note Ensure that you perform this task after configuring the pseudowire. If the VFI peer is configured before the pseudowire, the configuration is incomplete until the pseudowire is configured. The output of the **show running-config** command displays an error stating that configuration is incomplete.

```
Device# show running-config | sec vfi

l2 vfi config manual
 vpn id 1000
 ! Incomplete point-to-multipoint vfi config
```

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls label range** *minimum-value maximum-value* [**static** *minimum-static-value maximum-static-value*]
4. **pseudowire-class** [*pw-class-name*]
5. **encapsulation mpls**
6. **protocol** {**l2tpv2** | **l2tpv3** | **none**} *[l2tp-class-name]*
7. **exit**
8. **l2 vfi** *vfi-name* **manual**
9. **vpn id** *vpn-id*
10. **neighbor** *ip-address* **pw-class** *pw-name*
11. **mpls label** *local-pseudowire-label remote-pseudowire-label*
12. **mpls control-word**
13. **neighbor** *ip-address* **pw-class** *pw-name*
14. **mpls label** *local-pseudowire-label remote-pseudowire-label*
15. **mpls control-word**
16. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**mpls label range** *minimum-value maximum-value* [**static** *minimum-static-value maximum-static-value*] **Example:** `Device(config)# mpls label range 16 200 static 300 500`	Configures the range of local labels available for use with Multiprotocol Label Switching (MPLS) applications on packet interfaces.
Step 4	**pseudowire-class** [*pw-class-name*] **Example:** `Device(config)# pseudowire-class static_vpls`	Specifies the name of a Layer 2 pseudowire class and enters pseudowire class configuration mode.
Step 5	**encapsulation mpls** **Example:** `Device(config-pw-class)# encapsulation mpls`	Specifies the tunneling encapsulation as MPLS.
Step 6	**protocol** {**l2tpv2** | **l2tpv3** | **none**} *[l2tp-class-name]* **Example:** `Device(config-pw-class)# protocol none`	Specifies that no signaling protocol will be used in Layer 2 Tunneling Protocol Version 3 (L2TPv3) sessions.
Step 7	**exit** **Example:** `Device(config-pw-class)# exit`	Exits pseudowire class configuration mode and returns to global configuration mode.
Step 8	**l2 vfi** *vfi-name* **manual** **Example:** `Device(config)# l2 vfi static-vfi manual`	Establishes a Layer 2 VPN (L2VPN) virtual forwarding interface (VFI) between two or more separate networks, and enters Layer 2 VFI manual configuration mode.
Step 9	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 100`	Specifies the VPN ID.

	Command or Action	Purpose
Step 10	**neighbor** *ip-address* **pw-class** *pw-name* **Example:** `Device(config-vfi)# neighbor 10.3.4.4 pw-class static_vpls`	Specifies the IP address of the peer and the pseudowire class.
Step 11	**mpls label** *local-pseudowire-label remote-pseudowire-label* **Example:** `Device(config-vfi)# mpls label 301 17`	Configures an Any Transport over MPLS (AToM) static pseudowire connection by defining local and remote circuit labels.
Step 12	**mpls control-word** **Example:** `Device(config-vfi)# mpls control-word`	(Optional) Enables the MPLS control word in an AToM static pseudowire connection.
Step 13	**neighbor** *ip-address* **pw-class** *pw-name* **Example:** `Device(config-vfi)# neighbor 2.3.4.3 pw-class static_vpls`	Specifies the IP address of the peer and the pseudowire class.
Step 14	**mpls label** *local-pseudowire-label remote-pseudowire-label* **Example:** `Device(config-vfi)# mpls label 302 18`	Configures an AToM static pseudowire connection by defining local and remote circuit labels.
Step 15	**mpls control-word** **Example:** `Device(config-vfi)# mpls control-word`	(Optional) Enables the MPLS control word in an AToM static pseudowire connection.
Step 16	**end** **Example:** `Device(config-vfi)# end`	Exits Layer 2 VFI manual configuration mode and returns to privileged EXEC mode.

Configuring a VFI for Static VPLS: Alternate Configuration

Note Ensure that you perform this task after configuring the pseudowire. If the VFI peer is configured before the pseudowire, the configuration is incomplete until the pseudowire is configured. The output of the **show running-config** command displays an error stating that configuration is incomplete.

```
Device# show running-config | sec vfi

l2 vfi config manual
 vpn id 1000
 ! Incomplete point-to-multipoint vfi config
```

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **l2vpn vfi context** *vfi-name*
4. **vpn id** *vpn-id*
5. **exit**
6. **interface** *type number*
7. **encapsulation mpls**
8. **neighbor** *ip-address vc-id*
9. **label** *local-pseudowire-label remote-pseudowire-label*
10. **control-word** {**include** | **exclude**}
11. **exit**
12. **bridge-domain** *bd-id*
13. **member vfi** *vfi-name*
14. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**l2vpn vfi context** *vfi-name* **Example:** `Device(config)# l2vpn vfi context vpls1`	Establishes a Layer 2 VPN (L2VPN) virtual forwarding interface (VFI) between two or more separate networks and enters VFI configuration mode.

	Command or Action	Purpose
Step 4	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 100`	Specifies the VPN ID.
Step 5	**exit** **Example:** `Device(config-vfi)# exit`	Exits VFI configuration mode and returns to global configuration mode.
Step 6	**interface** *type number* **Example:** `Device(config)# interface pseudowire 100`	Specifies an interface and enters interface configuration mode.
Step 7	**encapsulation mpls** **Example:** `Device(config-if)# encapsulation mpls`	Specifies an encapsulation type for tunneling Layer 2 traffic over a pseudowire.
Step 8	**neighbor** *ip-address vc-id* **Example:** `Device(config-if)# neighbor 10.3.4.4 100`	Specifies the peer IP address and virtual circuit (VC) ID value of a Layer 2 VPN (L2VPN) pseudowire.
Step 9	**label** *local-pseudowire-label remote-pseudowire-label* **Example:** `Device(config-if)# label 301 17`	Configures an Any Transport over MPLS (AToM) static pseudowire connection by defining local and remote circuit labels.
Step 10	**control-word** {**include** | **exclude**} **Example:** `Device(config-if)# control-word include`	(Optional) Enables the Multiprotocol Label Switching (MPLS) control word in an AToM dynamic pseudowire connection.
Step 11	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.
Step 12	**bridge-domain** *bd-id* **Example:** `Device(config)# bridge-domain 24`	Specifies the bridge domain ID and enters bridge-domain configuration mode.
Step 13	**member vfi** *vfi-name* **Example:**	Binds a service instance to a bridge domain instance.

	Command or Action	Purpose
	`Device(config-bdomain)# member vfi vpls1`	
Step 14	**end** **Example:** `Device(config-bdomain)# end`	Exits bridge-domain configuration mode and returns to privileged EXEC mode.

Configuring an Attachment Circuit for Static VPLS

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface gigabitethernet** *slot/interface*
4. **service instance** *si-id* **ethernet**
5. **encapsulation dot1q** *vlan-id*
6. **rewrite ingress tag pop** *number* [**symmetric**]
7. **bridge-domain** *bd-id*
8. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface gigabitethernet** *slot/interface* **Example:** `Device(config)# interface gigabitethernet 0/0/1`	Specifies an interface and enters interface configuration mode. • Ensure that the interfaces between the customer edge (CE) and provider edge (PE) devices that run Ethernet over MPLS (EoMPLS) are in the same subnet. All other interfaces and backbone devices do not need to be in the same subnet.
Step 4	**service instance** *si-id* **ethernet** **Example:** `Device(config-if)# service instance 100 ethernet`	Configures an Ethernet service instance on an interface and enters service instance configuration mode.

	Command or Action	Purpose
Step 5	**encapsulation dot1q** *vlan-id* **Example:** `Device(config-if-srv)# encapsulation dot1q 200`	Defines the matching criteria to map 802.1Q frames ingress on an interface to the appropriate service instance. • Ensure that the interface on the adjoining CE device is on the same VLAN as this PE device.
Step 6	**rewrite ingress tag pop** *number* [**symmetric**] **Example:** `Device(config-if-srv)# rewrite ingress tag pop 1 symmetric`	(Optional) Specifies the encapsulation adjustment to be performed on a frame ingressing a service instance and the tag to be removed from a packet.
Step 7	**bridge-domain** *bd-id* **Example:** `Device(config-if-srv)# bridge-domain 24`	(Optional) Binds a service instance or a MAC tunnel to a bridge domain instance.
Step 8	**end** **Example:** `Device(config-if-srv)# end`	Exits service instance configuration mode and returns to privileged EXEC mode.

Configuring an Attachment Circuit for Static VPLS: Alternate Configuration

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface gigabitethernet** *slot/interface*
4. **service instance** *si-id* **ethernet**
5. **encapsulation dot1q** *vlan-id*
6. **rewrite ingress tag pop** *number* [**symmetric**]
7. **exit**
8. **exit**
9. **bridge-domain** *bd-id*
10. **member** *interface-type-number* **service-instance** *service-id* [**split-horizon group** *group-id*]
11. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface gigabitethernet** *slot/interface* **Example:** `Device(config)# interface gigabitethernet 0/0/1`	Specifies an interface and enters interface configuration mode. • Ensure that the interfaces between the customer edge (CE) and provider edge (PE) devices that are running Ethernet over MPLS (EoMPLS) are in the same subnet. All other interfaces and backbone devices do not need to be in the same subnet.
Step 4	**service instance** *si-id* **ethernet** **Example:** `Device(config-if)# service instance 10 ethernet`	Specifies a service instance ID and enters service instance configuration mode.
Step 5	**encapsulation dot1q** *vlan-id* **Example:** `Device(config-if-srv)# encapsulation dot1q 200`	Defines the matching criteria to map 802.1Q frames ingress on an interface to the appropriate service instance. • Ensure that the interface on the adjoining CE device is on the same VLAN as this PE device.
Step 6	**rewrite ingress tag pop** *number* [**symmetric**] **Example:** `Device(config-if-srv)# rewrite ingress tag pop 1 symmetric`	(Optional) Specifies the encapsulation adjustment to be performed on a frame ingressing a service instance and the tag to be removed from a packet.
Step 7	**exit** **Example:** `Device(config-if-srv)# exit`	Exits service instance configuration mode and returns to interface configuration mode.
Step 8	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.
Step 9	**bridge-domain** *bd-id* **Example:** `Device(config)# bridge-domain 100`	Specifies the bridge domain ID and enters bridge-domain configuration mode.

	Command or Action	Purpose
Step 10	**member** *interface-type-number* **service-instance** *service-id* [**split-horizon group** *group-id*] **Example:** `Device(config-bdomain)# member gigabitethernet0/0/1 service-instance 1000`	(Optional) Binds a service instance to a bridge domain instance.
Step 11	**end** **Example:** `Device(config-bdomain)# end`	Exits bridge-domain configuration mode and returns to privileged EXEC mode.

Configuring an MPLS-TP Tunnel for Static VPLS with TP

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface Tunnel-tp** *number*
4. **no ip address**
5. **no keepalive**
6. **tp destination** *ip-address*
7. **bfd** *bfd-template*
8. **working-lsp**
9. **out-label** *number* **out-link** *number*
10. **lsp-number** *number*
11. **exit**
12. **protect-lsp**
13. **out-label** *number* **out-link** *number*
14. **in-label** *number*
15. **lsp-number** *number*
16. **exit**
17. **exit**
18. **interface** *type number*
19. **ip address** *ip-address ip-mask*
20. **mpls tp link** *link-num* {**ipv4** *ip-address* | **tx-mac** *mac-address*}
21. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
	`Device> enable`	
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface Tunnel-tp** *number* **Example:** `Device(config)# interface Tunnel-tp 4`	Configures a Multiprotocol Label Switching (MPLS) transport profile tunnel and enters interface configuration mode. • Use the same interface as you configured for the pseudowire class.
Step 4	**no ip address** **Example:** `Device(config-if)# no ip address`	Disables the IP address configuration.
Step 5	**no keepalive** **Example:** `Device(config-if)# no keepalive`	Disables the keepalive configuration.
Step 6	**tp destination** *ip-address* **Example:** `Device(config-if)# tp destination 10.22.22.22`	Configures the tunnel destination.
Step 7	**bfd** *bfd-template* **Example:** `Device(config-if)# bfd tp`	Binds a single-hop Bidirectional Forwarding Detection (BFD) template to an interface.
Step 8	**working-lsp** **Example:** `Device(config-if)# working-lsp`	Configures the working label switched path (LSP) and enters working interface configuration mode.
Step 9	**out-label** *number* **out-link** *number* **Example:** `Device(config-if-working)# out-label 16 out-link 100`	Configures the out link and out label for the working LSP.
Step 10	**lsp-number** *number* **Example:**	Configures the ID number for the working LSP.

	Command or Action	Purpose
	`Device(config-if-working)# lsp-number 0`	
Step 11	**exit** **Example:** `Device(config-if-working)# exit`	Exits working interface configuration mode and returns to interface configuration mode.
Step 12	**protect-lsp** **Example:** `Device(config-if)# protect-lsp`	Enters protection configuration mode for the label switched path (LSP) and enters protect interface configuration mode.
Step 13	**out-label** *number* **out-link** *number* **Example:** `Device(config-if-protect)# out-label 11 out-link 500`	Configures the out link and out label for the protect LSP.
Step 14	**in-label** *number* **Example:** `Device(config-if-protect)# in-label 600`	Configures the in label for the protect LSP.
Step 15	**lsp-number** *number* **Example:** `Device(config-if-protect)# lsp-number 1`	Configures the ID number for the working protect LSP.
Step 16	**exit** **Example:** `Device(config-if-protect)# exit`	Exits protect interface configuration mode and returns to interface configuration mode.
Step 17	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.
Step 18	**interface** *type number* **Example:** `Device(config-if)# interface GigabitEthernet 0/1/0`	Configures a interface and enters interface configuration mode.
Step 19	**ip address** *ip-address ip-mask* **Example:** `Device(config)# ip address 10.0.0.1 255.255.255.0`	(Optional) Configures the IP address and mask if not using an IP-less core.

	Command or Action	Purpose
Step 20	**mpls tp link** *link-num* {**ipv4** *ip-address* | **tx-mac** *mac-address*} **Example:** `Device(config-if)# mpls tp link 10 tx-mac 0100.0c99.8877`	Configures Multiprotocol Label Switching (MPLS) transport profile (TP) link parameters.
Step 21	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configuring a VFI for Static VPLS: Alternate Configuration

Note Ensure that you perform this task after configuring the pseudowire. If the VFI peer is configured before the pseudowire, the configuration is incomplete until the pseudowire is configured. The output of the **show running-config** command displays an error stating that configuration is incomplete.

```
Device# show running-config | sec vfi

l2 vfi config manual
 vpn id 1000
 ! Incomplete point-to-multipoint vfi config
```

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **l2vpn vfi context** *vfi-name*
4. **vpn id** *vpn-id*
5. **exit**
6. **interface** *type number*
7. **encapsulation mpls**
8. **neighbor** *ip-address vc-id*
9. **label** *local-pseudowire-label remote-pseudowire-label*
10. **control-word** {**include** | **exclude**}
11. **exit**
12. **bridge-domain** *bd-id*
13. **member vfi** *vfi-name*
14. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Device> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**l2vpn vfi context** *vfi-name* **Example:** `Device(config)# l2vpn vfi context vpls1`	Establishes a Layer 2 VPN (L2VPN) virtual forwarding interface (VFI) between two or more separate networks and enters VFI configuration mode.
Step 4	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 100`	Specifies the VPN ID.
Step 5	**exit** **Example:** `Device(config-vfi)# exit`	Exits VFI configuration mode and returns to global configuration mode.
Step 6	**interface** *type number* **Example:** `Device(config)# interface pseudowire 100`	Specifies an interface and enters interface configuration mode.
Step 7	**encapsulation mpls** **Example:** `Device(config-if)# encapsulation mpls`	Specifies an encapsulation type for tunneling Layer 2 traffic over a pseudowire.
Step 8	**neighbor** *ip-address vc-id* **Example:** `Device(config-if)# neighbor 10.3.4.4 100`	Specifies the peer IP address and virtual circuit (VC) ID value of a Layer 2 VPN (L2VPN) pseudowire.
Step 9	**label** *local-pseudowire-label remote-pseudowire-label* **Example:** `Device(config-if)# label 301 17`	Configures an Any Transport over MPLS (AToM) static pseudowire connection by defining local and remote circuit labels.
Step 10	**control-word** {**include** | **exclude**} **Example:** `Device(config-if)# control-word include`	(Optional) Enables the Multiprotocol Label Switching (MPLS) control word in an AToM dynamic pseudowire connection.

	Command or Action	Purpose
Step 11	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode and returns to global configuration mode.
Step 12	**bridge-domain** *bd-id* **Example:** `Device(config)# bridge-domain 24`	Specifies the bridge domain ID and enters bridge-domain configuration mode.
Step 13	**member vfi** *vfi-name* **Example:** `Device(config-bdomain)# member vfi vpls1`	Binds a service instance to a bridge domain instance.
Step 14	**end** **Example:** `Device(config-bdomain)# end`	Exits bridge-domain configuration mode and returns to privileged EXEC mode.

Configuration Examples for Virtual Private LAN Services

Example: Configuring 802.1Q Access Ports for Tagged Traffic from a CE Device

This example shows how to configure the tagged traffic:

```
Device(config)# interface GigabitEthernet 0/0/1
Device(config-if)# no ip address
Device(config-if)# negotiation auto
Device(config-if)# service instance 10 ethernet
Device(config-if-srv)# encapsulation dot1q 200
Device(config-if-srv)# bridge-domain 100
Device(config-if-srv)# end
```

Example: Configuring 802.1Q Access Ports for Tagged Traffic from a CE Device: Alternate Configuration

The following example shows how to configure the tagged traffic:

```
Device(config)# interface GigabitEthernet 0/0/1
Device(config-if)# no ip address
Device(config-if)# negotiation auto
Device(config-if)# service instance 10 ethernet
Device(config-if-srv)# encapsulation dot1q 200
Device(config-if-srv)# exit
```

```
Device(config-if)# exit
Device(config)# bridge-domain 100
Device(config-bdomain)# member gigabitethernet0/0/1 service-instance 1000
Device(config-bdomain)# end
```

Example: Configuring Access Ports for Untagged Traffic from a CE Device

The following example shows how to configure access ports for untagged traffic:

```
Device(config)# interface gigabitethernet 0/0/0
Device(config-if)# no ip address
Device(config-if)# negotiation auto
Device(config-if)# service instance 10 ethernet
Device(config-if-srv)# encapsulation untagged
Device(config-if-srv)# bridge-domain 100
Device(config-if-srv)# end
```

The following example shows a virtual forwarding interface (VFI) configuration:

```
Device(config)# l2 vfi VPLSA manual
Device(config-vfi)# vpn id 110
Device(config-vfi)# neighbor 10.11.11.11 encapsulation mpls
Device(config-vfi)# neighbor 10.33.33.33 encapsulation mpls
Device(config-vfi)# neighbor 10.44.44.44 encapsulation mpls
Device(config-vfi)# bridge-domain 110
Device(config-vfi)# end
```

The following example shows a VFI configuration for hub and spoke.

```
Device(config)# l2 vfi VPLSB manual
Device(config-vfi)# vpn id 111
Device(config-vfi)# neighbor 10.99.99.99 encapsulation mpls
Device(config-vfi)# neighbor 10.12.12.12 encapsulation mpls
Device(config-vfi)# neighbor 10.13.13.13 encapsulation mpls no-split-horizon
Device(config-vfi)# bridge-domain 111
Device(config-vfi)# end
```

The output of the **show mpls l2transport vc** command displays various information related to a provide edge (PE) device. The VC ID in the output represents the VPN ID; the VC is identified by the combination of the destination address and the VC ID as shown in the command output. The output of the **show mpls l2transport vc detail** command displays detailed information about virtual circuits (VCs) on a PE device.

```
Device# show mpls l2transport vc 201

Local intf     Local circuit        Dest address    VC ID      Status
-------------  -------------------- --------------- ---------- ----------
VFI VPLSA      VFI                  10.11.11.11     110        UP
VFI VPLSA      VFI                  10.33.33.33     110        UP
VFI VPLSA      VFI                  10.44.44.44     110        UP
```

The following sample output from the **show vfi** command displays the VFI status:

```
Device# show vfi VPLSA
```

```
VFI name: VPLSA, state: up
  Local attachment circuits:
    Vlan2
  Neighbors connected via pseudowires:
  Peer Address     VC ID     Split-horizon
  10.11.11.11          110             Y
  10.33.33.33          110             Y
  10.44.44.44          110             Y


Device# show vfi VPLSB

VFI name: VPLSB, state: up
  Local attachment circuits:
    Vlan2
  Neighbors connected via pseudowires:
  Peer Address     VC ID     Split-horizon
  10.99.99.99       111             Y
  10.12.12.12       111             Y
  10.13.13.13       111             N
```

Example: Configuring Access Ports for Untagged Traffic from a CE Device: Alternate Configuration

The following example shows how to configure the untagged traffic.

```
Device(config)# interface GigabitEthernet 0/4/4
Device(config-if)# no ip address
Device(config-if)# negotiation auto
Device(config-if)# service instance 10 ethernet
Device(config-if-srv)# encapsulation untagged
Device(config-if-srv)# exit
Device(config-if)# exit
Device(config)# bridge-domain 100
Device(config-bdomain)# member GigabitEthernet0/4/4 service-instance 10
Device(config-if-srv)# end
```

Example: Configuring Q-in-Q EFP

The following example shows how to configure the tagged traffic.

```
Device(config)# interface GigabitEthernet 0/0/2
Device(config-if)# no ip address
Device(config-if)# negotiate auto
Device(config-if)# service instance 10 ethernet
Device(config-if-srv)# encapsulation dot1q 200 second-dot1q 400
Device(config-if-srv)# bridge-domain 100
Device(config-if-srv)# end
```

Use the **show spanning-tree vlan** command to verify that the ports are not in a blocked state. Use the **show vlan id** command to verify that a specific port is configured to send and receive specific VLAN traffic.

Example: Configuring Q-in-Q in EFP: Alternate Configuration

The following example shows how to configure the tagged traffic:

```
Device(config)# interface GigabitEthernet 0/4/4
Device(config-if)# no ip address
Device(config-if)# nonegotiate auto
Device(config-if)# service instance 10 ethernet
Device(config-if-srv)# encapsulation dot1q 200 second-dot1q 400
Device(config-if-srv)# exit
Device(config-if)# exit
Device(config)# bridge-domain 100
Device(config-bdomain)# member GigabitEthernet0/4/4 service-instance 1000
Device(config-bdomain)# end
```

Use the **show spanning-tree vlan** command to verify that the port is not in a blocked state. Use the **show vlan id** command to verify that a specific port is configured to send and receive a specific VLAN traffic.

Example: Configuring MPLS on a PE Device

The following example shows a global Multiprotocol Label Switching (MPLS) configuration:

```
Device(config)# mpls label protocol ldp
Device(config)# mpls ldp logging neighbor-changes
Device(config)# mpls ldp discovery hello holdtime 5
Device(config)# mpls ldp router-id Loopback0 force
```

The following sample output from the **show ip cef** command displays the Label Distribution Protocol (LDP) label assigned:

```
Device# show ip cef 192.168.17.7

192.168.17.7/32, version 272, epoch 0, cached adjacency to POS4/1
0 packets, 0 bytes
  tag information set
    local tag: 8149
    fast tag rewrite with PO4/1, point2point, tags imposed: {4017}
  via 10.3.1.4, POS4/1, 283 dependencies
    next hop 10.3.1.4, POS4/1
    valid cached adjacency
    tag rewrite with PO4/1, point2point, tags imposed: {4017}
```

Example: VFI on a PE Device

The following example shows a virtual forwarding instance (VFI) configuration:

```
Device(config)# l2 vfi vfi110 manual
Device(config-vfi)# vpn id 110
Device(config-vfi)# neighbor 172.16.10.2 4 encapsulation mpls
Device(config-vfi)# neighbor 10.16.33.33 encapsulation mpls
Device(config-vfi)# neighbor 198.51.100.44 encapsulation mpls
Device(config-vfi)# bridge-domain 100
```

```
Device(config-vfi)# end
```

The following example shows a VFI configuration for a hub-and-spoke configuration:

```
Device(config)# l2 vfi VPLSA manual
Device(config-vfi)# vpn id 110
Device(config-vfi)# neighbor 10.9.9.9 encapsulation mpls
Device(config-vfi)# neighbor 192.0.2.12 encapsulation mpls
Device(config-vfi)# neighbor 203.0.113.4 encapsulation mpls no-split-horizon
Device(config-vfi)# bridge-domain 100
Device(config-vfi)# end
```

The **show mpls 12transport vc** command displays information about the provider edge (PE) device. The **show mpls l2transport vc detail** command displays detailed information about the virtual circuits (VCs) on a PE device.

```
Device# show mpls l2transport vc 201

Local intf     Local circuit        Dest address    VC ID      Status
-------------  -------------------- --------------- ---------- ----------
VFI test1      VFI                  209.165.201.1   201        UP
VFI test1      VFI                  209.165.201.2   201        UP
VFI test1      VFI                  209.165.201.3   201        UP
```

The **show vfi** *vfi-name* command displays VFI status. The VC ID in the output represents the VPN ID; the VC is identified by the combination of the destination address and the VC ID as in the example below.

```
Device# show vfi VPLS-2

VFI name: VPLS-2, state: up
  Local attachment circuits:
    Vlan2
  Neighbors connected via pseudowires:
  Peer Address     VC ID     Split-horizon
  10.1.1.1          2             Y
  10.1.1.2          2             Y
  10.2.2.3          2             N
```

Example: VFI on a PE Device: Alternate Configuration

The following example shows how to configure a virtual forwarding interface (VFI) on a provider edge (PE) device:

```
Device(config)# l2vpn vfi context vfi110
Device(config-vfi)# vpn id 110
Device(config-vfi)# member 172.16.10.2 4 encapsulation mpls
Device(config-vfi)# member 10.33.33.33 encapsulation mpls
Device(config-vfi)# member 10.44.44.44 encapsulation mpls
Device(config-vfi)# exit
Device(config)# bridge-domain 100
Device(config-bdomain)# member vfi vfi110
Device(config-bdomain)# end
```

The following example shows how to configure a hub-and-spoke VFI configuration:.

```
Device(config)# l2vpn vfi context VPLSA
Device(config-vfi)# vpn id 110
Device(config-vfi)#  member 10.9.9.9 encapsulation mpls
Device(config-vfi)#  member 172.16.10.2 4 encapsulation mpls
Device(config-vfi)#  exit
Device(config)# bridge-domain 100
Device(config-bdomain)# member vfi VPLSA
Device(config-bdomain)# member GigabitEthernet0/0/0 service-instance 100
Device(config-bdomain)# member 10.33.33.33 10 encapsulation mpls
Device(config-bdomain)# end
```

The **show l2vpn atom vc** command displays information about the PE device. The command also displays information about Any Transport over MPLS (AToM) virtual circuits (VCs) and static pseudowires that are enabled to route Layer 2 packets on a device.

```
Device# show l2vpn atom vc

Local intf    Local circuit           Dest address    VC ID      Status
------------- ----------------------- --------------- ---------- ----------
Et0/0.1       Eth VLAN 101            10.0.0.2        101        UP
Et0/0.1       Eth VLAN 101            10.0.0.3        201        DOWN
```

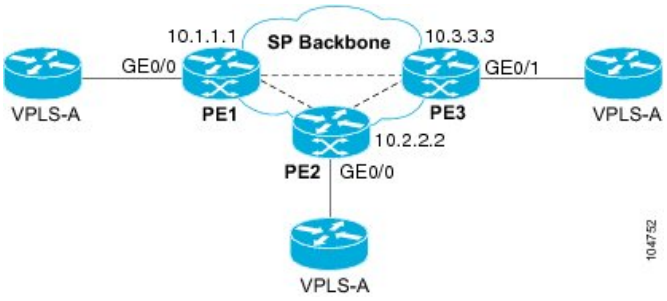
The **show l2vpn vfi** command displays the VFI status. The VC ID in the output represents the VPN ID; the VC is identified by the combination of the destination address and the VC ID as in the example below.

```
Device# show l2vpn vfi VPLS-2

Legend: RT= Route-target

VFI name: serviceCore1, State: UP, Signaling Protocol: LDP
  VPN ID: 100, VPLS-ID: 9:10, Bridge-domain vlan: 100
  RD: 9:10, RT: 10.10.10.10:150
  Pseudo-port Interface: Virtual-Ethernet1000

  Neighbors connected via pseudowires:
  Interface    Peer Address    VC ID      Discovered Router ID   Next Hop
  Pw2000       10.0.0.1        10         10.0.0.1               10.0.0.1
  Pw2001       10.0.0.2        10         10.1.1.2               10.0.0.2
  Pw2002       10.0.0.3        10         10.1.1.3               10.0.0.3
  Pw5          10.0.0.4        10         -                      10.0.0.4
```

Example: Full-Mesh VPLS Configuration

In a full-mesh configuration, each provider edge (PE) device creates a multipoint-to-multipoint forwarding relationship with all other PE devices in the Virtual Private LAN Services (VPLS) domain using a virtual forwarding interface (VFI). An Ethernet or a VLAN packet received from the customer network can be forwarded to one or more local interfaces and/or emulated virtual circuits (VCs) in the VPLS domain. To avoid a broadcast packet loop in the network, packets received from an emulated VC cannot be forwarded to any emulated VC in the VPLS domain on a PE device. Ensure that Layer 2 split horizon is enabled to avoid a broadcast packet loop in a full-mesh network.

Figure 7: Full-Mesh VPLS Configuration



PE 1 Configuration

The following examples shows how to create virtual switch instances (VSIs) and associated VCs:

```
l2 vfi PE1-VPLS-A manual
 vpn id 100
 neighbor 10.2.2.2 encapsulation mpls
 neighbor 10.3.3.3 encapsulation mpls
 bridge domain 100
!
interface Loopback 0
 ip address 10.1.1.1 255.255.0.0
```

The following example shows how to configure the customer edge (CE) device interface (there can be multiple Layer 2 interfaces in a VLAN):

```
interface GigabitEthernet 0/0/0
 no ip address
 negotiation auto
 service instance 10 ethernet
 encapsulation dot1q 200
 bridge-domain 100
```

PE 2 Configuration

The following example shows how to create VSIs and associated VCs.

```
l2 vfi PE2-VPLS-A manual
 vpn id 100
 neighbor 10.1.1.1 encapsulation mpls
 neighbor 10.3.3.3 encapsulation mpls
 bridge domain 100
!
interface Loopback 0
 ip address 10.2.2.2 255.255.0.0
```

The following example shows how to configure the CE device interface (there can be multiple Layer 2 interfaces in a VLAN):

```
interface GigabitEthernet 0/0/0
 no ip address
 negotiation auto
```

```
 service instance 10 ethernet
 encapsulation dot1q 200
 bridge-domain 100
```

PE 3 Configuration

The following example shows how to create VSIs and associated VCs:

```
l2 vfi PE3-VPLS-A manual
 vpn id 112
 neighbor 10.1.1.1 encapsulation mpls
 neighbor 10.2.2.2 encapsulation mpls
 bridge domain 100
!
interface Loopback 0
 ip address 10.3.3.3 255.255.0.0
```

The following example shows how to configure the CE device interface (there can be multiple Layer 2 interfaces in a VLAN).

```
interface GigabitEthernet 0/0/1
 no ip address
 negotiation auto
 service instance 10 ethernet
 encapsulation dot1q 200
 bridge-domain 100
!
```

The following sample output from the **show mpls l2 vc** command provides information about the status of the VC:

```
Device# show mpls l2 vc

Local intf       Local circuit        Dest address    VC ID      Status
-------------    -------------------- --------------- ---------- ----------
VFI PE1-VPLS-A   VFI                  10.2.2.2         100        UP
VFI PE1-VPLS-A   VFI                  10.3.3.3         100        UP
```

The following sample output from the **show vfi** command provides information about the VFI:

```
Device# show vfi PE1-VPLS-A

VFI name: VPLSA, state: up
  Local attachment circuits:
    Vlan200
  Neighbors connected via pseudowires:
    10.2.2.2  10.3.3.3
```

The following sample output from the **show mpls 12transport vc** command provides information about virtual circuits:

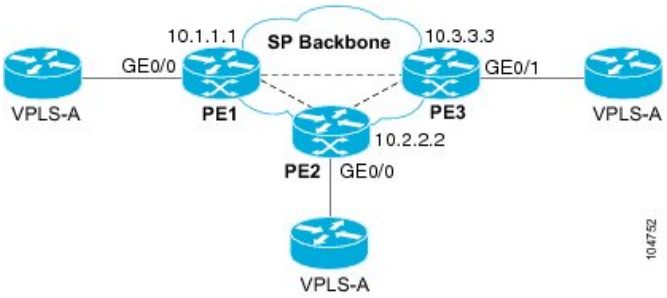
```
Device# show mpls l2transport vc detail

Local interface: VFI PE1-VPLS-A up
  Destination address: 10.2.2.2, VC ID: 100, VC status: up
    Tunnel label: imp-null, next hop point2point
```

```
    Output interface: Se2/0, imposed label stack {18}
  Create time: 3d15h, last status change time: 1d03h
  Signaling protocol: LDP, peer 10.2.2.2:0 up
    MPLS VC labels: local 18, remote 18
    Group ID: local 0, remote 0
    MTU: local 1500, remote 1500
    Remote interface description:
  Sequencing: receive disabled, send disabled
  VC statistics:
    packet totals: receive 0, send 0
    byte totals:   receive 0, send 0
    packet drops:  receive 0, send 0
```

Example: Full-Mesh Configuration : Alternate Configuration

In a full-mesh configuration, each provider edge (PE) router creates a multipoint-to-multipoint forwarding relationship with all other PE routers in the Virtual Private LAN Services (VPLS) domain using a virtual forwarding interface (VFI). An Ethernet or virtual LAN (VLAN) packet received from the customer network can be forwarded to one or more local interfaces and/or emulated virtual circuits (VCs) in the VPLS domain. To avoid broadcasted packets looping in the network, no packet received from an emulated VC can be forwarded to any emulated VC of the VPLS domain on a PE router. That is, Layer 2 split horizon should always be enabled as the default in a full-mesh network.

Figure 8: VPLS Configuration Example



PE 1 Configuration

The following example shows how to create virtual switch instances (VSIs) and associated VCs and to configure the CE device interface (there can be multiple Layer 2 interfaces in a VLAN):

```
interface gigabitethernet 0/0/0
 service instance 100 ethernet
 encap dot1q 100
 no shutdown
!
l2vpn vfi context PE1-VPLS-A
 vpn id 100
 neighbor 10.2.2.2 encapsulation mpls
 neighbor 10.3.3.3 encapsulation mpls
!
bridge-domain 100
 member gigabitethernet0/0/0 service-instance 100
 member vfi PE1-VPLS-A
```

PE 2 Configuration

The following example shows how to create VSIs and associated VCs and to configure the CE device interface (there can be multiple Layer 2 interfaces in a VLAN):

```
interface gigabitethernet 0/0/0
 service instance 100 ethernet
 encap dot1q 100
 no shutdown
!
l2vpn vfi context PE2-VPLS-A
 vpn id 100
 neighbor 10.1.1.1 encapsulation mpls
 neighbor 10.3.3.3 encapsulation mpls
!
bridge-domain 100
 member gigabitethernet0/0/0 service-instance 100
 member vfi PE2-VPLS-A
```

PE 3 Configuration

The following example shows how to create of the VSIs and associated VCs and to configure the CE device interface (there can be multiple Layer 2 interfaces in a VLAN):

```
interface gigabitethernet 0/0/0
 service instance 100 ethernet
 encap dot1q 100
 no shutdown
!
l2vpn vfi context PE3-VPLS-A
 vpn id 100
 neighbor 10.1.1.1 encapsulation mpls
 neighbor 10.2.2.2 encapsulation mpls
!
bridge-domain 100
 member gigabitethernet0/0/0 service-instance 100
 member vfi PE3-VPLS-A
```

The following sample output from the **show mpls l2 vc** command provides information on the status of the VC:

```
Device# show mpls l2 vc

Local intf       Local circuit  Dest address    VC ID      Status
-------------    -------------- --------------- ---------- ----------
VFI PE3-VPLS-A   VFI            10.2.2.2        100        UP
VFI PE3-VPLS-A   VFI            10.3.3.3        100        UP
```

The following sample output from the **show l2vpn vfi** command provides information about the VFI:

```
Device# show l2vpn vfi VPLS-2

Legend: RT= Route-target

VFI name: serviceCore1, State: UP, Signaling Protocol: LDP
  VPN ID: 100, VPLS-ID: 9:10, Bridge-domain vlan: 100
  RD: 9:10, RT: 10.10.10.10:150
```

```
Pseudo-port Interface: Virtual-Ethernet1000

Neighbors connected via pseudowires:
Interface    Peer Address    VC ID      Discovered Router ID   Next Hop
Pw2000       10.0.0.1        10         10.0.0.1               10.0.0.1
Pw2001       10.0.0.2        10         10.1.1.2               10.0.0.2
Pw2002       10.0.0.3        10         10.1.1.3               10.0.0.3
Pw5          10.0.0.4        10         -                      10.0.0.4
```

The following sample output from the **show l2vpn atom vc** command provides information on the virtual circuits:

```
Device# show l2vpn atom vc

Local intf    Local circuit           Dest address    VC ID      Status
------------- ----------------------- --------------- ---------- ----------
Et0/0.1       Eth VLAN 101            10.0.0.2        101        UP
Et0/0.1       Eth VLAN 101            10.0.0.3        201        DOWN
```

Feature Information for Configuring Virtual Private LAN Services

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 10: Feature Information for Configuring Virtual Private LAN Services

Feature Name	Releases	Feature Information
Configuring Virtual Private LAN Services	Cisco IOS XE Release 3.13.0S	This feature was introduced on the Cisco ASR 920 Routers (ASR-920-12CZ-A, ASR-920-12CZ-D, ASR-920-4SZ-A, ASR-920-4SZ-D).

Layer 2 Protocol Tunneling

Customers at different sites connected across a service-provider network need to use various Layer 2 protocols to scale their topologies to include all remote sites, as well as the local sites. STP must run properly, and every VLAN should build a proper spanning tree that includes the local site and all remote sites across the service-provider network. Cisco Discovery Protocol (CDP) must discover neighboring Cisco devices from local and remote sites.

VLAN Trunking Protocol (VTP) must provide consistent VLAN configuration throughout all sites in the customer network that are participating in VTP. Similarly, DTP, LACP, LLDP, PAgP, and UDLD can also run across the service-provider network.

When protocol tunneling is enabled, edge switches on the inbound side of the service-provider network encapsulate Layer 2 protocol packets with a special MAC address (0100.0CCD.CDD0) and send them across the service-provider network. Core switches in the network do not process these packets but forward them as normal (unknown multicast data) packets. Layer 2 protocol data units (PDUs) for the configured protocols

cross the service-provider network and are delivered to customer switches on the outbound side of the service-provider network. Identical packets are received by all customer ports on the same VLANs with these results:

- Users on each of a customer's sites can properly run STP, and every VLAN can build a correct spanning tree based on parameters from all sites and not just from the local site.
- CDP discovers and shows information about the other Cisco devices connected through the service-provider network.
- VTP provides consistent VLAN configuration throughout the customer network, propagating to all switches through the service provider that support VTP.

Customers use Layer 2 protocol tunneling to tunnel BPDUs through a service-provider network without interfering with internal provider network BPDUs.

Note Layer 2 protocol tunneling is supported on EFPs, but not on switchports.

Note EFP with Xconnect is enhanced to transparently forward the Layer 2 Control Protocol (L2CP) frames at the hardware level. Use the following command to forward the L2CP frames except the CFM frames:

```
mac-address-table evc-xconnect l2pt-forward-all
```

In addition to the listed L2CP frames, 802.1x (0x888E) frames and MACSec (0x88E5) frames can be forwarded over EoMPLS by enabling this command globally.

In figure below, Customer X has four switches in the same VLAN, which are connected through the service-provider network. If the network does not tunnel PDUs, switches on the far ends of the network cannot properly run STP, CDP, and other Layer 2 protocols. For example, STP for a VLAN on a switch in Customer X, Site 1, will build a spanning tree on the switches at that site without considering convergence parameters based on Customer X's switch in Site 2. This could result in the topology shown in figure below.

Figure 9: Layer 2 Protocol Tunneling

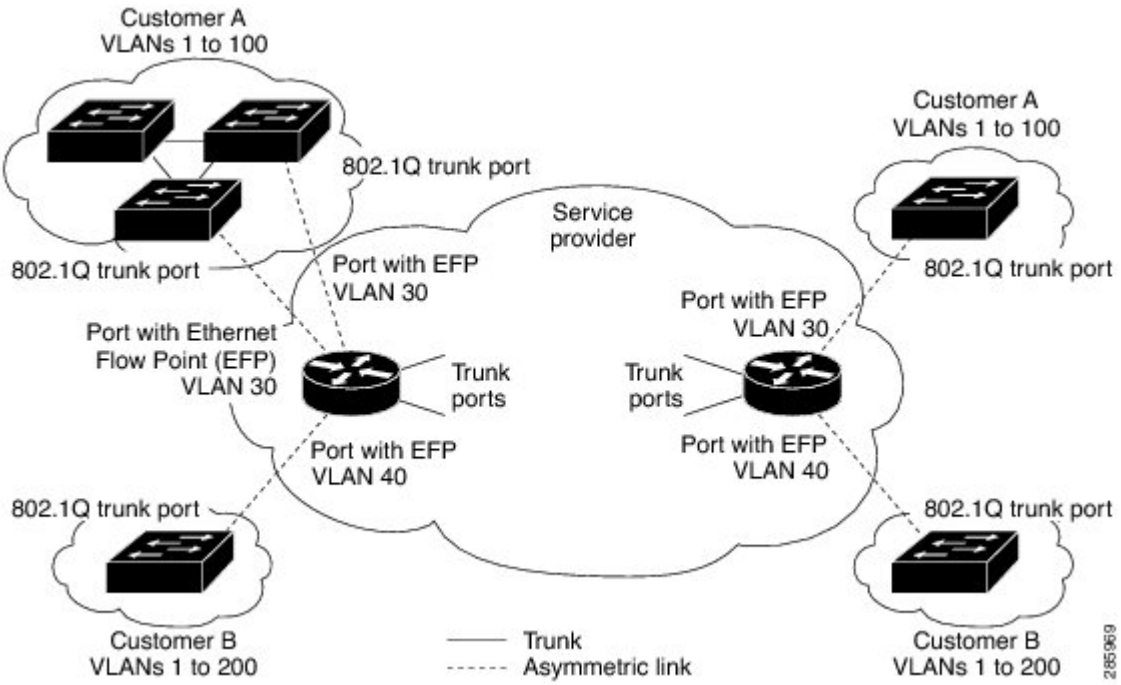
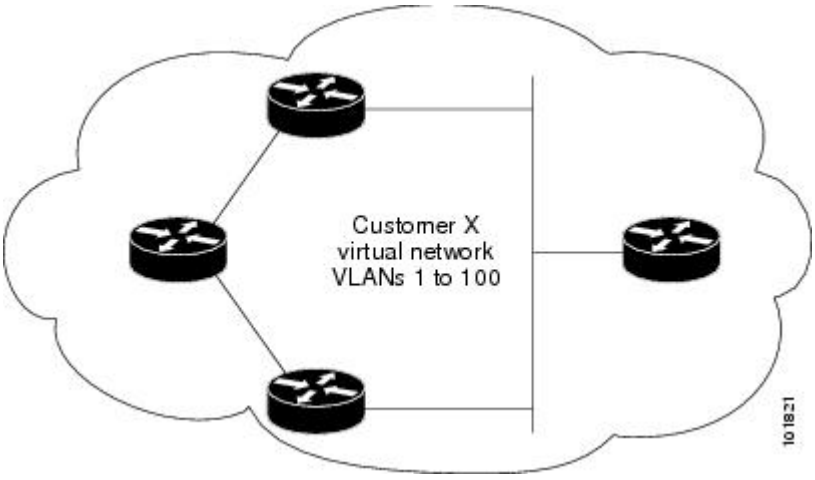


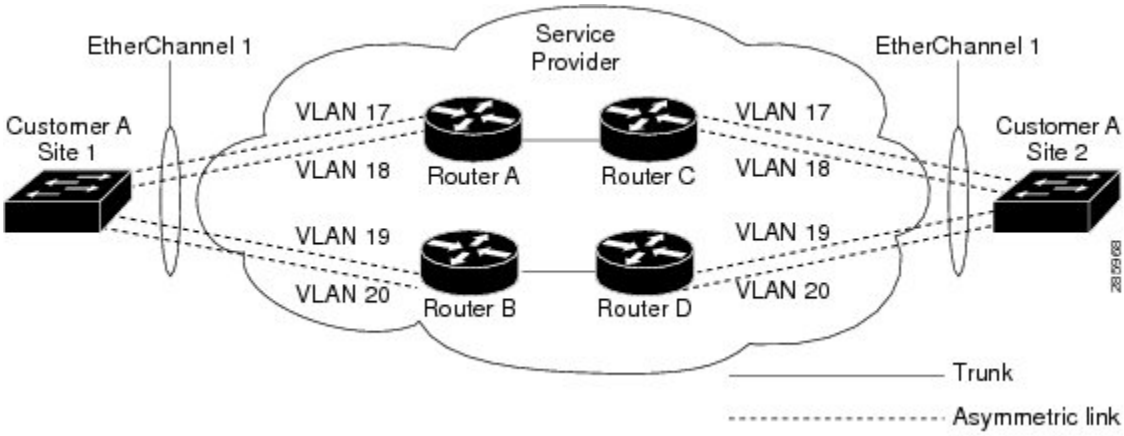
Figure 10: Layer 2 Network Topology without Proper Convergence



In a service-provider network, you can use Layer 2 protocol tunneling to enhance the creation of EtherChannels by emulating a point-to-point network topology. When you enable protocol tunneling (PAgP or LACP) on the service-provider switch, remote customer switches receive the PDUs and can negotiate the automatic creation of EtherChannels.

For example, in figure below, Customer A has two switches in the same VLAN that are connected through the SP network. When the network tunnels PDUs, switches on the far ends of the network can negotiate the automatic creation of EtherChannels without needing dedicated lines

Figure 11: Layer 2 Protocol Tunneling for EtherChannels



Use the **l2protocol tunnel***protocol* service-instance configuration command to enable Layer 2 protocol tunneling on a service instance

Valid protocols include CDP, LACP, LLDP, PAgP, STP, UDLD, and VTP. If a protocol is not specified for a service instance, the protocol frame is dropped at the interface.

This is an example of Layer 2 protocol tunneling configuration:

```
Router (config)# interface gigabitethernet0/2
Router (config-if)# service instance 10 Ethernet
Router (config-if-srv)# encapsulation untagged , dot1q 200 second-dot1q 300
Router (config-if-srv)# l2protocol tunnel cdp stp vtp pagp lacp
Router (config-if-srv)# bridge-domain 10
```

Note To enable tunneling of most Layer 2 protocol, you must configure **encapsulation untagged** because Layer 2 protocol PDUs are usually untagged.

Layer 2 protocol tunneling statistics

The following command is used to view the Layer 2 protocol tunneling statistics:

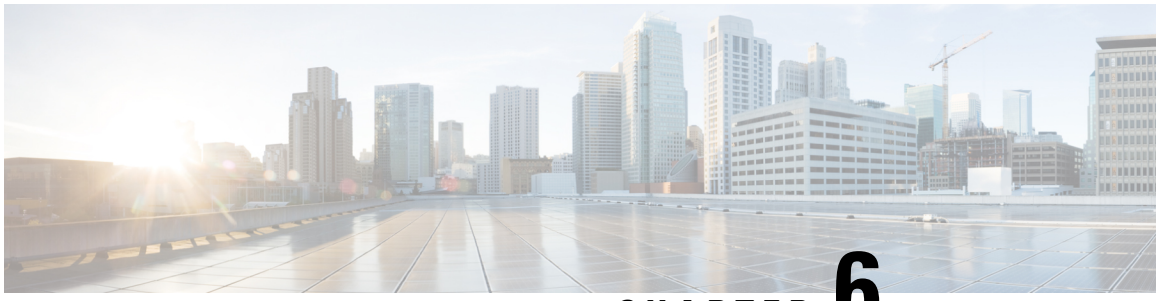
show ethernet service instance id *service-instance id*interface *interface* platform

This is an example of Layer 2 protocol tunneling statistics:

```
2020#sh run int gi0/0/9
Building configuration...

Current configuration : 228 bytes
interface GigabitEthernet0/0/9
 no ip address
 media-type auto-select
 negotiation auto
 no keepalive
 service instance 200 ethernet
  encapsulation untagged
  l2protocol tunnel
  xconnect 2.2.2.2 1 encapsulation mpls
end
```

```
2020#show ethernet service instance id 200 inter gig 0/0/9 platform

Service Instance (EFP) L2 PDU Handing Info

EFP               CDP   STP   VTP   DTP   PAGP  LLDP  LACP  UDLD  LOAM  ESMC  ELMI  PTPPD
 RES4  RES5  RES6  RES8  RES9  RESA  RESB  RESC  RESD  RESF  CFG  NH
-------------------------------------------------------------------------------------------
Gi0/0/9.Efp200    TUNL  TUNL  TUNL  DROP  TUNL  TUNL  TUNL  TUNL  TUNL  TUNL  TUNL  TUNL
 TUNL  TUNL  TUNL  TUNL  TUNL  TUNL  TUNL  TUNL  TUNL  TUNL  Y    N

EFP L2PT Tunnel statistics
----------------------------------------
L2protocol        Encapped      Decapped
----------------------------------------
CDP:              0             0
STP:              4059          13661
VTP:              0             0
DTP:              0             0
PAGP:             0             0
LLDP:             0             0
LACP:             0             0
UDLD:             0             0
LOAM:             0             0
ESMC:             0             0
ELMI:             0             0
PTPPD:            0             0
```

Note Layer 2 Protocol Tunnel decap statistics increments on core port for Layer 2 Protocol Tunnel over BD/VPLS scenario and Layer 2 Protocol Tunnel.



CHAPTER 6

H-VPLS N-PE Redundancy for MPLS Access

The H-VPLS N-PE Redundancy for MPLS Access feature enables two network provider edge (N-PE) devices to provide failover services to a user provider edge (U-PE) device in a hierarchical virtual private LAN service (H-VPLS). Having redundant N-PE devices provides improved stability and reliability against link and node failures.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for H-VPLS N-PE Redundancy for MPLS Access

- Before configuring this feature, configure your hierarchical virtual private LAN service (H-VPLS) network and make sure it is operating correctly.
- To provide faster convergence, you can enable the MPLS Traffic Engineering—Fast Reroute feature in the Multiprotocol Label Switching (MPLS) core.
- Enable the L2VPN Pseudowire Redundancy feature on the user provider edge (U-PE) devices for MPLS access.

Restrictions for H-VPLS N-PE Redundancy for MPLS Access

- This feature cannot be used with the VPLS Autodiscovery feature on pseudowires that attach to user provider edge (U-PE) devices. When you create the virtual private LAN service (VPLS), you can manually create the virtual forwarding interface (VFI).
- You cannot configure more than one pseudowire to carry the bridge protocol data unit (BPDU) information between the network provider edge (N-PE) devices.
- You cannot configure a local loopback address as a neighbor when you configure the H-VPLS N-PE Redundancy feature on N-PE devices.
- Only two N-PE devices can be connected to each U-PE device.

Information About H-VPLS N-PE Redundancy for MPLS Access

How H-VPLS N-PE Redundancy for MPLS Access

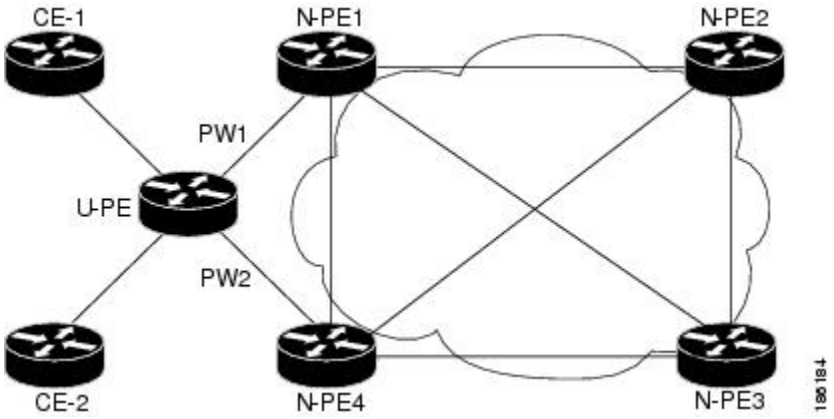
In a network configured with the H-VPLS N-PE Redundancy feature, the user provider edge (U-PE) device is connected to two network provider edge (N-PE) devices. This feature provides a level of redundancy that can tolerate both link and device faults. If a failure occurs in the network that disables one N-PE device from transmitting data, the other N-PE device takes over.

H-VPLS N-PE Redundancy with MPLS Access Based on Pseudowire Redundancy

For the H-VPLS Redundancy with MPLS Access feature based on pseudowire redundancy, the Multiprotocol Label Switching (MPLS) network has pseudowires to the virtual private LAN service (VPLS) core network provider edge (N-PE) devices.

As shown in the figure below, one pseudowire transports data between the user provider edge (U-PE) device and its peer N-PE devices. When a failure occurs along the path of the U-PE device, the backup pseudowire and the redundant N-PE device become active and start transporting data.

Figure 12: H-VPLS N-PE Redundancy for MPLS Access Based on Pseudowire Redundancy



How to Configure H-VPLS N-PE Redundancy for MPLS Access

Configuring the VPLS Pseudowire Between the N-PE Devices

Configuring network provider edge (N-PE) redundancy in a hierarchical Virtual Private LAN service (H-VPLS) network requires that you define the VPLS pseudowire for transporting bridge protocol data unit (BPDU) packets (described here) and that you connect that pseudowire to the native VLAN (described in the next task). This configuration provides a redundancy that provides improved reliability against link and node failures.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **l2 vfi** *name* **manual**
4. **vpn id** *id-number*
5. **bridge-domain** *bridge-id*
6. **neighbor** *remote-router-id vc-id* {**encapsulation** *encapsulation-type* | **pw-class** *pw-name*} [**no-split-horizon**]
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Device# configure terminal`	
Step 3	**l2 vfi** *name* **manual** **Example:** `Device(config)# l2 vfi vfitest1 manual`	Creates a Layer 2 virtual forwarding interface (VFI) and enters Layer 2 VFI manual configuration mode.
Step 4	**vpn id** *id-number* **Example:** `Device(config-vfi)# vpn id 10`	Specifies the VPN ID.
Step 5	**bridge-domain** *bridge-id*	Configures the router to derive bridge domains from the encapsulation VLAN list.
Step 6	**neighbor** *remote-router-id vc-id* {**encapsulation** *encapsulation-type* | **pw-class** *pw-name*} [**no-split-horizon**] **Example:** `Device(config-vfi)# neighbor 10.2.2.2 3 encapsulation mpls`	Specifies the peer IP address of the redundant N-PE device and the type of tunnel signaling and encapsulation mechanism.
Step 7	**end** **Example:** `Device(config-vfi)# end`	Exits Layer 2 VFI manual configuration mode and returns to privileged EXEC mode.

Example

You can also configure the VPLS pseudowire between the N-PE devices using this alternate method.

```
RoutDeviceer> enable
Device# configure terminal
Device(config)# l2vpn vfi context vfi110
Device(config-vfi)# vpn id 10
Device(config-vfi)# exit
Device(config)# bridge-domain 100
Device(config-bdomain)# member vfi vfi110
Device(config-vfi)# member 172.16.10.2 4 encapsulation mpls
Device(config-vfi)# end
```

Configuring the SVI for the Native VLAN

Perform this task to configure the switched virtual interface (SVI) for the native VLAN and verify that it is correctly configured.

SUMMARY STEPS

1. **enable**

2. **configure terminal**
3. **interface vlan** *vlan-id*
4. **xconnect vfi** *vfi-name*
5. **end**
6. **show vfi** *vfi-name*
7. **end**

DETAILED STEPS

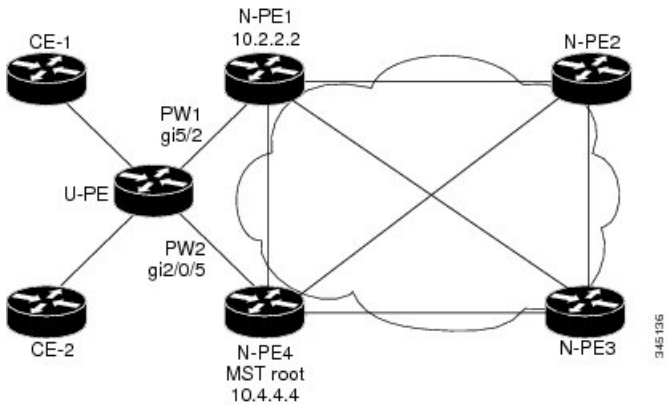
	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface vlan** *vlan-id* **Example:** `Device(config)# interface vlan 23`	Creates a dynamic SVI. • To make the SVI active when you create a VLAN, you must configure the VLAN with at least one physical interface that is in the "up" state. Use the **show vfi** command to display the status of the SVI. The state field will display "up" when the SVI is active.
Step 4	**xconnect vfi** *vfi-name* **Example:** `Device(config)# xconnect vfi vfitest1`	Specifies the Layer 2 virtual forwarding interface (VFI) that you are binding to the VLAN port.
Step 5	**end** **Example:** `Device(config-vfi)# end`	Ends the current configuration session and returns to privileged EXEC mode.
Step 6	**show vfi** *vfi-name* **Example:** `Device# show vfi VPLS-2`	(Optional) Displays information about the pseudowire between the two network provider edge (N-PE) devices so that you can verify that the H-VPLS N-PE Redundancy feature is correctly configured.
Step 7	**end** **Example:** `Device# end`	Exits privileged EXEC mode and returns to user EXEC mode.

Configuration Examples for H-VPLS N-PE Redundancy for MPLS Access

Example: H-VPLS N-PE Redundancy for MPLS Access

The figure below shows a configuration that is set up for the H-VPLS N-PE Redundancy with MPLS Access feature.

Figure 13: H-VPLS N-PE Redundancy with MPLS Access Topology



The table below shows the configuration of two network provider edge (N-PE) devices.

Table 11: Example: H-VPLS N-PE Redundancy for MPLS Access

N-PE1	N-PE4

`l2 vfi l2trunk manual`
` vpn id 10`
`bridge-domain 10`
 	
` neighbor 10.4.4.4 encapsulation mpls`
`!`
 	
`spanning-tree mode mst`
`spanning-tree extend system-id`
`!`
`spanning-tree mst configuration`
` revision 10`
` instance 1 vlan 20`
`!`
 	
`interface GigabitEthernet 0/5/2`
`service instance 5 ethernet`
`encapsulation dot1q 10`
`bridge-domain 10`
	`l2 vfi l2trunk manual`
	` vpn id 10`
	`bridge-domain 10`
	
	` neighbor 10.2.2.2 encapsulation mpls`
	`!`
	
	`spanning-tree mode mst`
	`spanning-tree extend system-id`
	`!`
	`spanning-tree mst configuration`
	` revision 10`
	` instance 1 vlan 20`
	`!`
	`spanning-tree mst 1 priority 0`
	`!`
	
	`interface GigabitEthernet 0/5/2`
	`service instance 5 ethernet`
	`encapsulation dot1q 10`
	`bridge-domain 10`

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
MPLS commands	Cisco IOS Multiprotocol Label Switching Command Reference
L2VPN pseudowire redundancy	"L2VPN Pseudowire Redundancy" feature module in the *MPLS Layer 2 VPNs Configuration Guide*.
H-VPLS	" Configuring VPLS " in the "Configuring Multiprotocol Label Switching on the Optical Services Modules" chapter in the *Optical Services Modules Installation and Configuration Notes*, 12.2SR document.
MPLS traffic engineering	"MPLS Traffic Engineering Fast Reroute Link and Node Protection" feature module in the *MPLS Traffic Engineering: Path, Link, and Node Protection Configuration Guide* (part of the Multiprotocol Label Switching Configuration Guide Library)

Standards

Standard	Title
http://www.ietf.org/rfc/rfc4447.txt	*Pseudowire Setup and Maintenance Using the Label Distribution Protocol (LDP)*
http://www3.ietf.org/proceedings/06mar/IDs/draft-ietf-l2vpn-vpls-ldp-08.txt	*Virtual Private LAN Services over MPLS*
http://www.ietf.org/internet-drafts/draft-ietf-pwe3-segmented-pw-02.txt	*Segmented Pseudo Wire*
draft-ietf-pwe3-vccv-10.txt	*Pseudo Wire Virtual Circuit Connectivity Verification (VCCV)*
draft-ietf-pwe3-oam-msg-map-03.txt	*Pseudo Wire (PW) OAM Message Mapping*

MIBs

MIB	MIBs Link
Pseudowire Emulation Edge-to-Edge MIBs for Ethernet, Frame Relay, and ATM Services	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for H-VPLS N-PE Redundancy for MPLS Access

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 12: Feature Information for H-VPLS N-PE Redundancy for MPLS Access

Feature Name	Releases	Feature Information
H-VPLS N-PE Redundancy for MPLS Access	Cisco IOS XE Release 3.13.0S	This feature was introduced on the Cisco ASR 920 Routers (ASR-920-12CZ-A, ASR-920-12CZ-D, ASR-920-4SZ-A, ASR-920-4SZ-D).

Glossary

CE device—customer edge device. A device that belongs to a customer network, which connects to a PE device to utilize MPLS VPN network services.

LAN—local-area network. High-speed, low-error data network covering a relatively small geographic area. LANs connect workstations, peripherals, terminals, and other devices in a single building or other geographically limited areas.

MPLS—Multiprotocol Label Switching. A packet-forwarding technology, used in the network core, that applies data link layer labels to tell switching nodes how to forward data, resulting in faster and more scalable forwarding than network layer routing normally can do.

MSTP—Multiple Spanning Tree Protocol. MSTP enables multiple VLANs to be mapped to the same spanning-tree instance, reducing the number of spanning-tree instances needed to support a large number of VLANs.

N-PE—network provider edge device. This device acts as a gateway between the MPLS core and edge domains.

PE device—provider edge device. The PE device is the entry point into the service provider network. The PE device is typically deployed on the edge of the network and is administered by the service provider.

pseudowire—A pseudowire is a virtual connection that, in the context of VPLS, connects two SVIs. It is a mechanism that carries the elements of an emulated service from one PE device to one or more PE devices over a packet switched network (PSN). A pseudowire is bidirectional and consists of a pair of unidirectional MPLS virtual circuits (VCs). A pseudowire can be used to connect a point-to-point circuit.

QinQ—An IEEE 802.1Q VLAN tunnel. A mechanism for constructing multipoint Layer 2 VPN using Ethernet switches.

redundancy—The duplication of devices, services, or connections so that, in the event of a failure, they can perform the work of those that failed.

router—A network layer device that uses one or more metrics to determine the optimal path along which network traffic should be forwarded. Routers forward packets from one network to another based on network layer information.

spanning tree—Loop-free subset of a network topology.

U-PE—user provider edge device. This device connects CE devices to the service.

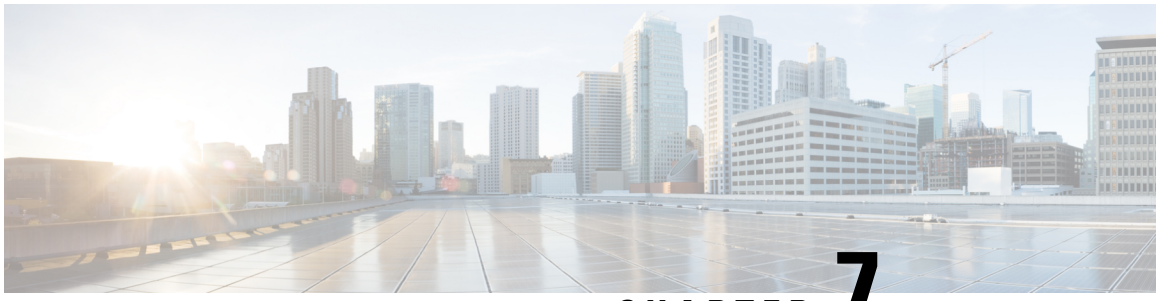
VFI—virtual forwarding instance. A VFI is a collection of data structures used by the data plane, software-based or hardware-based, to forward packets to one or more VCs.

VLAN—Virtual LAN. Group of devices on one or more LANs that are configured (using management software) so that they can communicate as if they were attached to the same wire, when in fact they are located on a number of different LAN segments.

VPLS—Virtual Private LAN Service. VPLS describes an architecture that delivers Layer 2 service that emulates an Ethernet LAN across a wide-area network (WAN) and inherits the scaling characteristics of a LAN.

VPLS redundancy—Also called N-PE redundancy. Allows U-PEs to be dual-honed (to their N-PEs) in a loop-free topology with MPLS or QinQ as the access or aggregation domain.

VPN—Virtual Private Network. Allows IP traffic to travel securely over public TCP/IP networks and the Internet by encapsulating and encrypting all IP packets. VPN uses a tunnel to encrypt all information at the IP level.



CHAPTER 7

VPLS MAC Address Withdrawal

The VPLS MAC Address Withdrawal feature provides faster convergence by removing (or unlearning) MAC addresses that have been dynamically learned. A Label Distribution Protocol (LDP)-based MAC address withdrawal message is used for this purpose. A MAC list Type Length Value (TLV) is part of the MAC address withdrawal message. No configuration is needed.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About VPLS MAC Address Withdrawal

VPLS MAC Address Withdrawal

The VPLS MAC Address Withdrawal feature provides faster convergence by removing (or unlearning) MAC addresses that have been dynamically learned. A Label Distribution Protocol (LDP)-based MAC address withdrawal message is used for this purpose. A MAC list Type Length Value (TLV) is part of the MAC address withdrawal message.

The **debug mpls ldp messages** and **debug mpls ldp session io** commands support monitoring of MAC address withdrawal messages being exchanged between LDP peers. Any Transport over Multiprotocol Label Switching (AToM) might provide other means to display or monitor MAC address withdrawal messages. The Tag Distribution Protocol (TDP) is not supported because AToM uses only LDP for the MAC address withdrawal message.

PE devices learn the remote MAC addresses and directly attached MAC addresses on customer-facing ports by deriving the topology and forwarding information from packets originating at customer sites. To display the number of MAC address withdrawal messages, enter the **show mpls l2transport vc detail** command, as shown in the following example:

```
Device# show mpls l2transport vc detail

Local interface: VFI TEST VFI up
  MPLS VC type is VFI, interworking type is Ethernet
  Destination address: 10.1.1.1, VC ID: 1000, VC status: up
    Output interface: Se2/0, imposed label stack {17}
    Preferred path: not configured
    Default path: active
    Next hop: point2point
  Create time: 00:04:34, last status change time: 00:04:15
  Signaling protocol: LDP, peer 10.1.1.1:0 up
    Targeted Hello: 10.1.1.1(LDP Id) -> 10.1.1.1
    MPLS VC labels: local 16, remote 17
    Group ID: local 0, remote 0
    MTU: local 1500, remote 1500
    Remote interface description:
    MAC Withdraw: sent 5, received 3
  Sequencing: receive disabled, send disabled
  VC statistics:
    packet totals: receive 0, send 0
    byte totals:   receive 0, send 0
    packet drops:  receive 0, send 0
```

VPLS MAC Address Withdrawal Using Commands Associated with L2VPN Protocol-Based Feature

The VPLS MAC Address Withdrawal feature provides faster convergence by removing (or unlearning) MAC addresses that have been dynamically learned. A Label Distribution Protocol (LDP)-based MAC address withdrawal message is used for this purpose. A MAC list Type Length Value (TLV) is part of the MAC address withdrawal message.

The **debug mpls ldp messages** and **debug mpls ldp session io** commands support monitoring of MAC address withdrawal messages being exchanged between LDP peers. Any Transport over Multiprotocol Label Switching (AToM) might provide other means to display or monitor MAC address withdrawal messages. The Tag Distribution Protocol (TDP) is not supported because AToM uses only LDP for the MAC address withdrawal message.

PE devices learn the remote MAC addresses and directly attached MAC addresses on customer-facing ports by deriving the topology and forwarding information from packets originating at customer sites. To display the number of MAC address withdrawal messages, enter the **show l2vpn atom vc detail** command, as shown in the following example:

```
Device# show l2vpn atom vc detail

Local interface: VFI TEST VFI up
  MPLS VC type is VFI, interworking type is Ethernet
  Destination address: 10.1.1.1, VC ID: 1000, VC status: up
    Output interface: Se2/0, imposed label stack {17}
    Preferred path: not configured
    Default path: active
    Next hop: point2point
  Create time: 00:04:34, last status change time: 00:04:15
```

```
Signaling protocol: LDP, peer 10.1.1.1:0 up
  Targeted Hello: 10.1.1.1(LDP Id) -> 10.1.1.1
  MPLS VC labels: local 16, remote 17
  Group ID: local 0, remote 0
  MTU: local 1500, remote 1500
  Remote interface description:
  MAC Withdraw: sent 5, received 3
Sequencing: receive disabled, send disabled
VC statistics:
  packet totals: receive 0, send 0
  byte totals:   receive 0, send 0
  packet drops:  receive 0, send 0
```

How MAC Address Withdrawal Works with H-VPLS N-PE Redundancy with MPLS Access

If the pseudowire between the user provider edge (U-PE) device and network provider edge (N-PE) device fails, the L2VPN Pseudowire Redundancy feature on the U-PE device activates the standby pseudowire. In addition, the U-PE device sends a Label Distribution Protocol (LDP) MAC address withdrawal request to the new N-PE device, which forwards the message to all pseudowires in the virtual private LAN service (VPLS) core and flushes its MAC address table.

If a bridge domain interface (BDI) on the N-PE device fails, the L2VPN Pseudowire Redundancy feature activates the standby pseudowire and the U-PE device sends a MAC withdrawal message to the newly active N-PE device.

How MAC Address Withdrawal Works with H-VPLS N-PE Redundancy with QinQ Access

If a failure occurs in the customer-switched network, a spanning-tree Topology Change Notification (TCN) is issued to the network provider edge (N-PE) device, which issues a Label Distribution Protocol (LDP)-based MAC address withdrawal message to the peer N-PE devices and flushes its MAC address table.

Additional References for Any Transport over MPLS

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
MPLS commands	Cisco IOS Multiprotocol Label Switching Command Reference

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

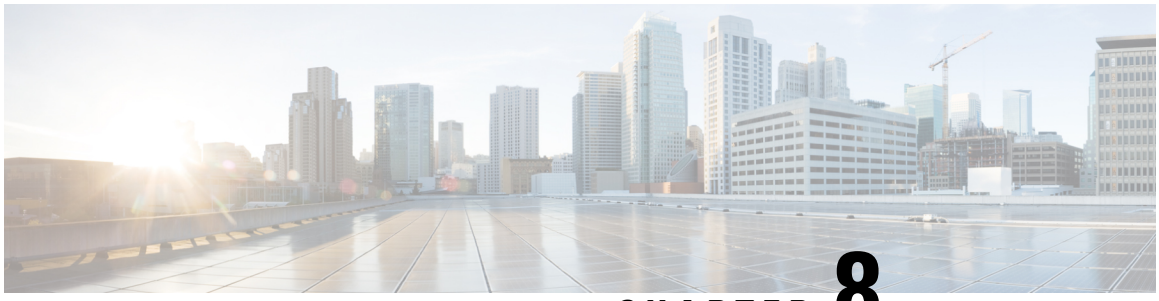
Feature Information for VPLS MAC Address Withdrawal

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 13: Feature Information for VPLS MAC Address Withdrawal

Feature Name	Releases	Feature Information
VPLS MAC Address Withdrawal	Cisco IOS XE Release 3.13.0S	This feature was introduced on the Cisco ASR 920 Routers (ASR-920-12CZ-A, ASR-920-12CZ-D, ASR-920-4SZ-A, ASR-920-4SZ-D).



CHAPTER 8

VPLS BGP Signaling

The two primary functions of the Virtual Private LAN Service (VPLS) control plane are autodiscovery and signaling. The VPLS BGP Signaling feature enables you to use BGP as both an autodiscovery and a signaling protocol for VPLS, in accordance with RFC 4761.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for VPLS BGP Signaling

You are familiar with the concepts in the “Configuring Virtual Private LAN Services” and the “VPLS Autodiscovery BGP Based” modules of the MPLS Layer 2 VPNs Configuration Guide .

Information About VPLS BGP Signaling

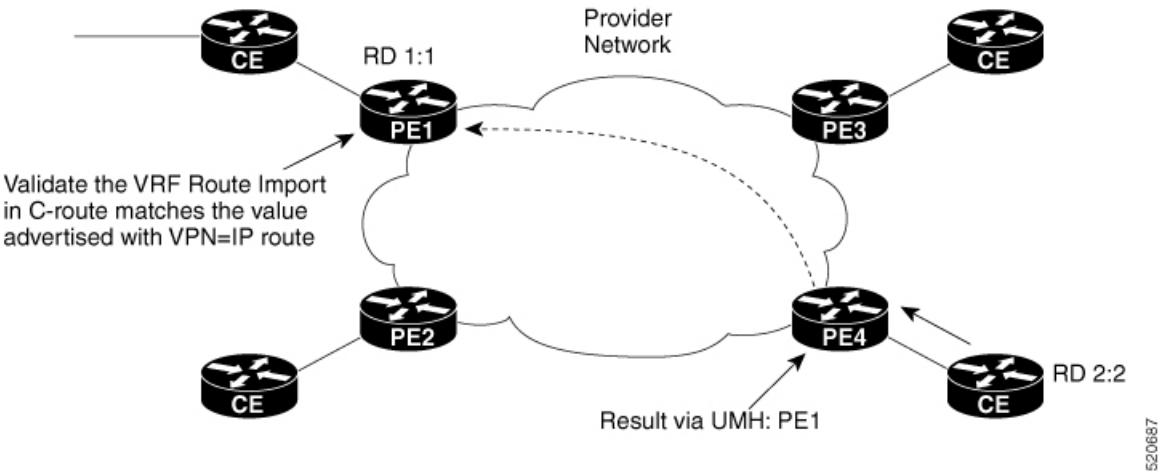
Overview of VPLS BGP Signaling

Prior to the VPLS BGP Signaling feature, BGP was used for autodiscovery and Label Distribution Protocol (LDP) for signaling in accordance with RFC 6074. The VPLS BGP Signaling feature enables you to use BGP as the control plane protocol for both autodiscovery and signaling in accordance with RFC 4761.

As specified in RFC 4761, internal BGP (iBGP) peers will exchange update messages of the L2VPN AFI/SAFI with L2VPN information to perform both autodiscovery and signaling. The BGP multiprotocol Network Layer Reachability Information (NLRI) consists of a Route Distinguisher (RD), VPLS Endpoint ID (VE ID), VE Block Offset (VBO), VE Block Size (VBS), and Label Base (LB).

The figure below shows the format of the NLRI for RFC 4761.

Figure 14: RFC 4761 NLRI



Additional information, such as next-hop, route target (specified for a VPLS instance), and other Layer 2 data are carried in the BGP extended community attributes. A route target-based import/export mechanism similar to L3VPN is performed by BGP to filter L2VPN NLRIs of a particular VPLS instance.

Whether you use BGP signaling (RFC 4761) or LDP signaling (RFC 6074) depends on the commands you specify. To enable the VPLS BGP Signaling feature, use the **autodiscovery bgp signaling bgp** command in L2 VFI configuration mode. This command is supported on a per VPLS instance basis.

If a BGP session receives an invalid (that is, not matching the configuration) BGP update advertisement (update or withdraw), it is ignored.

BGP's main task in supporting VPLS is route distribution via the L2VPN address family and interactions with L2VPN. Interactions between BGP and other components remain the same. Basic BGP functionalities like best-path selection, next-hop handling, and update generation, continue to operate in the same manner with VPLS BGP signaling. BGP RT constraint works seamlessly with the BGP VPLS Signaling feature.

The above example shows sample configuration on one PE. Similar configuration can be mirrored on other PEs.

How to Configure VPLS BGP Signaling

Configuring VPLS BGP Signaling

Before you begin

Note For more information, see Configuring Virtual Private Lan Services.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **l2vpn vfi context** *name*
4. **vpn id** *vpn-id*
5. **autodiscovery bgp signaling** {**bgp** | **ldp**} [**template** *template-name*]
6. **ve id** *ve-id*
7. **ve range** *ve-range*
8. **exit**
9. **exit**
10. **router bgp** *autonomous-system-number*
11. **bgp graceful-restart**
12. **neighbor** *ip-address* **remote-as** *autonomous-system-number*
13. **address-family l2vpn** [**vpls**]
14. **neighbor** *ip-address* **activate**
15. **neighbor** *ip-address* **send-community** [**both** | **standard** | **extended**]
16. **neighbor** *ip-address* **suppress-signaling-protocol ldp**
17. **end**
18. **show bgp l2vpn vpls** {**all** | **rd** *route-distinguisher*}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**l2vpn vfi context** *name* **Example:** `Device(config)# l2vpn vfi context vfi1`	Establishes a L2VPN virtual forwarding interface (VFI) between two or more separate networks and enters Layer 2 VFI configuration mode.
Step 4	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 100`	Configures a VPN ID for the VPLS domain.
Step 5	**autodiscovery bgp signaling** {**bgp** | **ldp**} [**template** *template-name*] **Example:** `Device(config-vfi)# autodiscovery bgp signaling bgp`	Enables BGP signaling and discovery or LDP signaling and enters L2VPN VFI autodiscovery configuration mode. **Note** For the VPLS BGP Signaling feature use the **autodiscovery bgp signaling bgp** command.
Step 6	**ve id** *ve-id* **Example:** `Device(config-vfi-autodiscovery)# ve id 1001`	Specifies the VPLS endpoint (VE) device ID value. The VE ID identifies a VFI within a VPLS service. The VE device ID value is from 1 to 16384.
Step 7	**ve range** *ve-range* **Example:** `Device(config-vfi-autodiscovery)# ve range 12`	Specifies the VE device ID range value. The VE range overrides the minimum size of VE blocks. The default minimum size is 10. Any configured VE range must be higher than 10.
Step 8	**exit** **Example:** `Device(config-vfi-autodiscovery)# exit`	Exits L2VPN VFI autodiscovery configuration mode and enters L2VPN VFI configuration mode.
Step 9	**exit** **Example:** `Device(config-vfi)# exit`	Exits L2VPN VFI configuration mode and enters global configuration mode.
Step 10	**router bgp** *autonomous-system-number* **Example:** `Device(config)# router bgp 100`	Enters router configuration mode to create or configure a BGP routing process.
Step 11	**bgp graceful-restart** **Example:** `Device(config-router)# bgp graceful-restart`	Enables the BGP graceful restart capability and BGP nonstop forwarding (NSF) awareness.

	Command or Action	Purpose
Step 12	**neighbor** *ip-address* **remote-as** *autonomous-system-number* **Example:** `Device(config-router)# neighbor 10.10.10.1 remote-as 100`	Configures peering with a BGP neighbor in the specified autonomous system.
Step 13	**address-family l2vpn** [**vpls**] **Example:** `Device(config-router)# address-family l2vpn vpls`	Specifies the L2VPN address family and enters address family configuration mode. • The optional **vpls** keyword specifies that VPLS endpoint provisioning information is to be distributed to BGP peers. In this example, an L2VPN VPLS address family session is created.
Step 14	**neighbor** *ip-address* **activate** **Example:** `Device(config-router-af)# neighbor 10.10.10.1 activate`	Enables the neighbor to exchange information for the L2VPN VPLS address family with the local device.
Step 15	**neighbor** *ip-address* **send-community** [**both** | **standard** | **extended**] **Example:** `Device(config-router-af)# neighbor 10.10.10.1 send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor. • In this example, an extended communities attribute is sent to the neighbor at 10.10.10.1.
Step 16	**neighbor** *ip-address* **suppress-signaling-protocol ldp** **Example:** `Device(config-router-af)# neighbor 10.10.10.1 suppress-signaling-protocol ldp`	Suppresses LDP signaling and enables BGP signaling. • In this example LDP signaling is suppressed (and BGP signaling enabled) for the neighbor at 10.10.10.1.
Step 17	**end** **Example:** `Device(config-router-af)# end`	Exits address family configuration mode and returns to privileged EXEC mode.
Step 18	**show bgp l2vpn vpls** {**all** | **rd** *route-distinguisher*} **Example:** `Device# show bgp l2vpn vpls all`	(Optional) Displays information about the L2VPN VPLS address family.

Configuration Examples for VPLS BGP Signaling

Example: Configuring and Verifying VPLS BGP Signaling

```
l2vpn vfi context vfi1
 vpn id 100
 autodiscovery bgp signaling bgp
  ve id 1001
  ve range 10
 !
!
router bgp 100
 bgp graceful-restart
 neighbor 209.165.200.224 remote-as 100
 neighbor 209.165.200.224 update-source Loopback1
 !
 address-family l2vpn vpls
  neighbor 209.165.200.224 activate
  neighbor 209.165.200.224 send-community extended
  neighbor 209.165.200.224 suppress-signaling-protocol ldp
  exit-address-family
 !
show bgp l2vpn vpls all

Network                          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 100:100
*>100:100:VEID-1001:Blk-1001/136    0.0.0.0                              32768  ?

*>i 100:100:VEID-1003:Blk-1000/136  209.165.200.224              0      100     0     ?
```

Additional References for VPLS BGP Signaling

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
BGP commands: complete command syntax, command mode, defaults, command history, usage guidelines, and examples.	Cisco IOS IP Routing: BGP Command Reference
Configuring Virtual Private LAN Services	MPLS Layer 2 VPNs Configuration Guide
Configuring Access Port	Configuring Virtual Private LAN Services, MPLS Layer 2 VPNs Configuration Guide

Related Topic	Document Title
VPLS Autodiscovery BGP Based	MPLS Layer 2 VPNs Configuration Guide

Standards and RFCs

Standard/RFC	Title
RFC 4761	*Virtual Private LAN Service (VPLS) Using BGP for Auto-Discovery and Signaling*
RFC 6074	*Provisioning, Auto-Discovery, and Signaling in Layer 2 Virtual Private Networks (L2VPNs)*

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

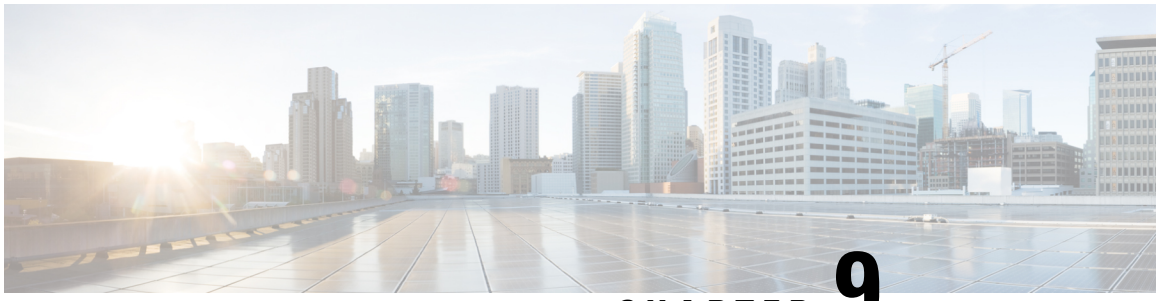
Feature Information for VPLS BGP Signaling

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 14: Feature Information for VPLS BGP Signaling

Feature Name	Releases	Feature Information
VPLS BGP Signaling		The VPLS BGP Signaling feature enables you to use BGP as both an autodiscovery and signaling protocol for VPLS, in accordance with RFC 4761. The following commands were introduced or modified: **autodiscovery (MPLS)**, **neighbor suppress-signaling-protocol**, **show bgp l2vpn vpls**, and **ve**. In Cisco IOS XE Release 3.8S, support was added for the Cisco ASR 903 router.



CHAPTER 9

EVPN Virtual Private Wire Service (VPWS) Single Homed

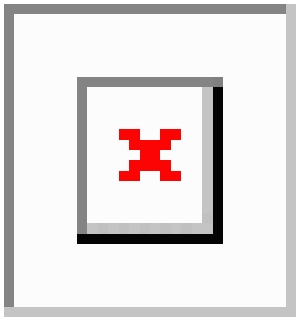
Effective Release Cisco IOS XE 3.18, this feature is now supported on Cisco ASR 920 Series Aggregation Services Router, EVPN-VPWS single homed is a BGP control plane solution for point-to-point services. It has the ability to forward traffic from or to one network to another using the Ethernet Segment without MAC lookup.

EVPN VPWS single homed technology works on IP and MPLS core. IP core to support BGP and MPLS core for switching packets between the endpoints.

Information About EVPN-VPWS

The EVPN-VPWS solution supports per EVI Ethernet Auto Discovery route. EVPN defines a new BGP Network Layer Reachability Information (NLRI) used to carry all EVPN routes. BGP Capabilities Advertisement used to ensure that two speakers support EVPN NLRI (AFI 25, SAFI 70) as per RFC 4760.

The architecture for EVPN VPWS is that the PEs run Multi-Protocol BGP in control-plane. The following image describes the EVPN-VPWS configuration:



Benefits of EVPN-VPWS Single Homed

- Scalability is achieved without signaling pseudowires.
- There is ease of provisioning.
- Pseudowires (PWs) are not used.
- EVPN-VPWS Single Homed leverages BGP best-path selection (optimal forwarding).

Prerequisites for EVPN-VPWS

- Ensure BGP is configured for EVPN SAFI.
- MPLS LDP core is used for MPLS LSP between PE. MPLS LDP core is required when Segement Routing is not used.
- CE-facing interface, such as service instance, is Ethernet family without IP address on PE.
- BGP session between PEs with 'address-family l2vpn evpn' to exchange EVPN routes.
- A BGP Route Reflector is supported.
- IGP, such as ISIS, core for IP reachability between PEs and BGP next-hop reachability.

Restrictions for EVPN-VPWS

- The combination of EVPN ID and VPWS Instance ID must be unique according to ASN.
- MPLS TE core is *not* supported.
- InterAS Option B is *not* supported.
- NSR is *not* supported for l2vpn family.
- Ensure NSF is configured on BGP, OSPF(iBGP), and MPLS.
- NSF is supported, you should see neigh flap, but not traffic drop.
- Without NSF, if you are doing Stateful SwitchOver (SSO), then you would see traffic drop for l2vpn evpn traffic.
- ELB is *not* supported on EVPN

Scaling Information

Number of supported EVPN-VPWS service instances is 2000 on Cisco ASR 920 Series Aggregation Services Router.

How to Configure EPVN-VPWS

The following steps are performed to configure EVPN-VPWS

- Configuring BGP for EVPN-VPWS
- Configuring EVPN-VPWS Instance

Configuring BGP for EVPN-VPWS

To configure EVPN-VPWS in BGP, follow these steps:

Procedure

```
router bgp 1
address-family l2vpn evpn
neighbor 192.168.0.1 activate
exit-address-family
```

Configuring EVPN-VPWS Instance

To configure EVPN VPWS instance, follow these steps:

Procedure

```
enable
configure terminal
l2vpn evpn instance 11 point-to-point
vpws context test
service target 100 source 100
member GigabitEthernet0/0/0 service-instance 10
no shut
end
```

Rewrite for EVI Service Instance

You need to have the rewrite command when the VLANs are mismatched on the remote ACs. This allows ingress traffic movement. To configure EVPN-VPWS service instance for rewrite, follow these steps:

Procedure

```
interface GigabitEthernet0/0/1
service instance 2 ethernet
encapsulation dot1q 2
rewrite ingress tag pop 1 symmetric
end
```

Configuring EVPN-VPWS for Logging

To configure EVPN-VPWS for logging, follow these steps:

Procedure

```
enable
configure terminal
l2vpn evpn logging vc-state
end
```

Verfiying EVPN-VPWS Instance

Verifying EVPN-VPWS Configuration

You can verify the configuration using the following show commands:

- **show l2vpn evpn summary**
- **show l2vpn evpn evi (<evpn-id> | all) [detail]**
- **show l2vpn evpn rib ead [detail] |evi**
- **show l2vpn evpn checkpoint**
- **show l2vpn evpn route-target [<rt>]**
- **show bgp l2vpn evpn**
- **show l2vpn evpn memory [detail]**

This command displays a summary of L2VPN EVPN with total number of EVIs, VCs and routes.

```
show l2vpn evpn summary

L2VPN EVPN VPWS:
  EVIs (point-to-point): 1
  Total VCs: 1
    1 up, 0 down, 0 admin-down, 0 hot-standby, 0 other
  Total EVPN EAD routes: 2
    1 local, 1 remote
  Total EVI EAD routes: 2
    1 local, 1 remote (1 in-use)
  BGP: ASN 1, address-family l2vpn evpn configured
  Router ID: 192.168.0.2
```

This command displays brief or detail info for EVIs.

```
show l2vpn evpn evi 100 det

EVPN instance: 100 (point-to-point)
  RD: 192.168.0.2:100 (auto)
  Import-RTs: 1:100
  Export-RTs: 1:100
  Total VCs: 1
    1 up, 0 down, 0 admin-down, 0 hot-standby, 0 other
  Total EAD routes: 2
    1 local, 1 remote (1 in-use)
```

This command displays the contents of the global EVPN route.

```
show l2vpn evpn rib ead

+- Origin of entry                                (i=iBGP/e=eBGP/L=Local)
| +- Best path                                    (Yes/No)?
| |
```

```
v v
O B         RD              Ethernet Segment Id    Eth Tag     Next Hop
-+-+---------------------+-----------------------+--------+---------------
i Y 192.168.0.3:100       0000.0000.0000.0000.0000 2        192.168.0.3
L - 192.168.0.2:100       0000.0000.0000.0000.0000 1
```

```
show l2vpn evpn rib ead evi

+- Origin of entry                                (i=iBGP/e=eBGP/L=Local)
| +- Provisioned                                  (Yes/No)?
| | +- Best path                                  (Yes/No)?
| | |
v v v
O P B  EVI    Ethernet Segment Id    Eth Tag     Next Hop      Label
-+-+-+-----+-----------------------+--------+---------------+--------
i Y Y 100   0000.0000.0000.0000.0000 2        192.168.0.3     16
L - - 100   0000.0000.0000.0000.0000 1                        16
```

```
show l2vpn evpn checkpoint

EVPN Checkpoint info for active RP
Checkpointing is allowed
Bulk-sync checkpointed state for 0 VC
ISSU Context:95, Compatible:1, Negotiated L2HW types: 0
```

This command displays the contents of the global route-target (RT).

```
show l2vpn evpn route-target

Route Target           EVPN Instances
1:100                  100
```

```
show bgp l2vpn evpn

BGP table version is 4, local router ID is 192.168.0.2
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 192.168.0.2:100
 *>  [1][192.168.0.2:100][00000000000000000000][5]/23
                        ::                                   32768 ?
Route Distinguisher: 192.168.0.3:100
 *>i [1][192.168.0.3:100][00000000000000000000][6]/23
                        192.168.0.3              0    100      0 ?
```

This command displays brief or detail EVPN memory usage.

```
show l2vpn evpn memory

  Allocator-Name                  In-use/Allocated            Count
  ------------------------------------------------------------------------------
  EVPN DB                   :        648/65632      (  0%) [      9] Chunk
  EVPN EAD DB               :        432/65632      (  0%) [      6] Chunk
  EVPN EAD Handle Table     :      21856/22040      ( 99%) [      2]
  EVPN EAD Paths            :        104/65632      (  0%) [      1] Chunk
  EVPN EAD Routes           :         96/65648      (  0%) [      2] Chunk
  EVPN RIB MGR              :        976/1344       ( 72%) [      4]
  EVPN RIB NHs              :          0/10096      (  0%) [      0] Chunk
  EVPN RIB RTs              :         96/10096      (  0%) [      2] Chunk
  EVPN RIB msg              :          0/10096      (  0%) [      0] Chunk
  EVPN Thread               :       1684/2144       ( 78%) [      5]
  EVPN context chunk        :        768/32864      (  2%) [      1] Chunk
```

```
 EVPN context handle table :      70968/71152      ( 99%) [      2]
 EVPN dtrace elem per-cont :       1280/65632      (  1%) [     20] Chunk
 EVPN dtrace stridx        :    1194876/1194968    ( 99%) [      1]
 EVPN dtrace stridx freeli :     132764/132856     ( 99%) [      1]
 EVPN dtrace stridx hash   :         76/168        ( 45%) [      1]
 EVPN dtrace stridx slots  :     265532/265624     ( 99%) [      1]
 EVPN dtrace stridx2slot   :     132764/132856     ( 99%) [      1]
 EVPN instance chunk       :        168/10096      (  1%) [      1] Chunk
 EVPN rt-db ee             :        124/216        ( 57%) [      1]
 EVPN rt-db rte            :        204/296        ( 68%) [      1]

 Total allocated: 2.121 Mb, 2172 Kb, 2225088 bytes
```

Verifying EVPN-VPWS Configuration for Logging

You can verify the logging using the **show l2vpn evpn vc** command.

This command displays brief information for VCs.

```
show l2vpn evpn vc all

 EVPN ID Source   Target   Type   Name/Interface                   Status
------- -------- -------- ------ -------------------------------- ----------
100     1        2        p2p    vc100                            up
                                 Et0/0                            up
```

This command displays detail information for VCs.

```
show l2vpn evpn vc all detail

 EVPN name: vc100, state: up, type: point-to-point
  EVPN ID: 100
  VPWS Service Instance ID:  Source 1, Target 2
  Labels:  Local 16, Remote 16
  Next Hop Address: 192.168.0.3
  Associated member Et0/0 is up, status is up
  Dataplane:
    SSM segment/switch IDs: 4098/4097 (used), PWID: 1
  Rx Counters
    78 input transit packets, 26425 bytes
    0 drops
  Tx Counters
    79 output transit packets, 28240 bytes
    0 drops
  5 VC FSM state transitions, Last 5 shown
    Prov: Idle -> Prov, Tue Sep 29 13:15:37.848 (00:52:21 ago)
    AdmUp: Prov -> LocWait, Tue Sep 29 13:15:40.287 (00:52:18 ago)
    LocUp: LocWait -> RemWait, Tue Sep 29 13:15:40.287 (00:52:18 ago)
    RemUp: RemWait -> Act, Tue Sep 29 13:17:19.368 (00:50:39 ago)
    DpUp: Act -> Est, Tue Sep 29 13:17:19.371 (00:50:39 ago)
```

Troubleshooting

Virtual Circuit (VC) is in Down state

EVPN VPWS protocol has no communication of VC state between endpoints. Furthemore LDP transport LSP is unidirectional and there is no end-to-end checking for connectivity. VC can be up on one end and down on the other end in the following cases:

- Core-facing mpls dataplane down on one side only. For example, if loopback configured with /24 on one-end and configured correctly with /32 at other end.

- UUT has no remote EVPN EAD route from peer. Several variants:
  - Peer never sent it.
  - Peer sent it, but RT mismatch: No intersection between UUT Import-RT and peer Export-RT.
  - Peer sent it, RT matches, but etag mismatch: For service etags tgt/src, UUT has x/y, peer has y/z.

Problem VC is in down state.

Possible Cause None

Solution Perform these steps to check whether the VC is not active:

Solution

- **Solution** Check if any VC is not active.
- **Solution** Identify EVIs that has not got an active VCs
- **Solution** Gather information for the EVIs that has not got an active VCs
- **Solution** Locate the not active VCs for the EVI
- **Solution** Display detail information of the not active VC

Solution

```
show l2vpn evpn vc all detail
EVPN name: vc100, state: up, type: point-to-point
  EVPN ID: 100
  VPWS Service Instance ID:  Source 1, Target 2
  Labels:  Local 16, Remote 16

// Must have a valid Local Label. If missing, contact support.

// Must have valid Remote Label. If missing, then there is no matching remote route.
Cross-check with BGP: 'show bgp l2vpn evpn [...] detail'.

  Next Hop Address: 192.168.0.3

// Must have valid Next Hop Address. If missing, then there is no matching remote route.
Cross-check with BGP: 'show bgp l2vpn evpn [...] detail'.

  Associated member Et0/0 is up, status is up

// AC must be up. If not up, check why.

  Dataplane:
    SSM segment/switch IDs: 4098/4097 (used), PWID: 1
  Rx Counters
    78 input transit packets, 26425 bytes
    0 drops
  Tx Counters
    79 output transit packets, 28240 bytes
    0 drops
  5 VC FSM state transitions, Last 5 shown
    Prov: Idle -> Prov, Tue Sep 29 13:15:37.848 (00:52:21 ago)
    AdmUp: Prov -> LocWait, Tue Sep 29 13:15:40.287 (00:52:18 ago)
    LocUp: LocWait -> RemWait, Tue Sep 29 13:15:40.287 (00:52:18 ago)
    RemUp: RemWait -> Act, Tue Sep 29 13:17:19.368 (00:50:39 ago)
    DpUp: Act -> Est, Tue Sep 29 13:17:19.371 (00:50:39 ago)
```

```
// Pay close attention to last line of VC FSM history. The format is:
// <Event>: <OldState> -> <NewState>
// Troubleshooting info appears below.
```

VC FSM History

Problem The state of the VC is Prov — Provisioned: VC is disabled.

Possible Cause None

Solution Perform these steps for a solution to the state:

Solution

- Check BGP is running.
- Check BGP 'address-family l2vpn evpn' is configured.
- Check VC is not shutdown.

Problem The state of the VC is LocWait — Local-Wait: Waiting for local AC information to come up.

Possible Cause None

Solution Check AC is up.

Problem The state of the VC is Act — Activating: Control plane ok. Trying to activate dataplane.

Possible Cause None

Solution

- Check core facing information is up.
- Check LDP on core facing information.

Remote-Wait State

Problem The state of the VC is RemWait — Remote-Wait: Waiting for matching remote route.

Possible Cause This state occurs due to no matching remote route for the VC. A matching remote route means all of the following are true:

- Route is present in BGP. Requires a local EVI to have route target in the route.
- Remote path is best path.
- Route is present in global EVPN route.
- Route is present in EVI route. Requires the EVI to have route target in the route.
- Route has ETag which matches the VC source identity. (**service target <tgt-id> source <src-id>**).

Solution Perform these steps to check whether the VC is in remote wait state:

Solution

- Check for EVI configuration mismatch.
- Check for VC configuration mismatch.
- Check if the remote route is present in BGP.
    - If no remote route then check if
        - remote route was discarded by BGP due to RT filter
        - peer did not send route to UUT
        - EVI or VC configuration mismatch
        - all the prerequisites are satisfied

- If a remote route is present in global EVPN then check if the remote route is present in EVI route.
  - **Solution** Check for EVI or VC configuration mismatch.

Configuration Examples for EVPN-VPWS Instance

The following example is for configuration for an EVPN-VPWS instance.

Example: EVPN-VPWS Instance Configuration

```
Router(config)#l2vpn evpn instance 11 point-to-point
Router(config-evpn-evi)#rd 1:1
Router(config-evpn-evi)#vpws context test
Router(config-evpn-vpws)#service target 100 source 100
Router(config-evpn-vpws)#member GigabitEthernet0/0/0 service-instance 10
Router(config-evpn-vpws)#no shut
```

The following example has running configurations on PE1 and PE2

Example: EVPN-VPWS PE1 configuration

```
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
 ip ospf 1 area 0
!
interface GigabitEthernet0/0/0
 description CE1 facing
 no ip address
!
service instance 300 ethernet
   encapsulation dot1q 300
   rewrite ingress tag pop 1 symmetric

 l2vpn evpn instance 100 point-to-point
 !
 vpws context vc100
 service target 2 source 1
 member GigabitEthernet0/0/0 service-instance 300
!
interface GigabitEthernet0/0/1
 description Core facing
 ip address 10.0.1.1 255.255.255.0
 ip ospf 1 area 0
 mpls ip
!
router ospf 1
 router-id 1.1.1.1
!
router bgp 1
 bgp router-id 1.1.1.1
 neighbor 2.2.2.2 remote-as 1
 neighbor 2.2.2.2 update-source Loopback0
 !
 address-family ipv4
  neighbor 2.2.2.2 activate
 exit-address-family
 !
```

```
 address-family l2vpn evpn
  neighbor 2.2.2.2 activate
 exit-address-family
!
l2vpn evpn instance 100 point-to-point
 !
 vpws context vc100
  service target 2 source 1
  member GigabitEthernet0/0/0
!
mpls ldp router-id Loopback0
!
```

Example: EVPN-VPWS PE2 configuration

```
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
 ip ospf 1 area 0
!
interface GigabitEthernet0/0/0
 description CE2 facing
 no ip address
!
service instance 300 ethernet
   encapsulation dot1q 300
   rewrite ingress tag pop 1 symmetric

 l2vpn evpn instance 100 point-to-point
 !
 vpws context vc100
 service target 2 source 1
 member GigabitEthernet0/0/0 service-instance 300

interface GigabitEthernet0/0/1
 description Core facing
 ip address 10.0.1.2 255.255.255.0
 ip ospf 1 area 0
 mpls ip
!
router ospf 1
 router-id 2.2.2.2
!
router bgp 1
 bgp router-id 2.2.2.2
 neighbor 1.1.1.1 remote-as 1
 neighbor 1.1.1.1 update-source Loopback0
 !
 address-family ipv4
  neighbor 1.1.1.1 activate
 exit-address-family
 !
 address-family l2vpn evpn
  neighbor 1.1.1.1 activate
 exit-address-family
!
l2vpn evpn instance 100 point-to-point
 !
 vpws context vc100
  service target 1 source 2
  member GigabitEthernet0/0/0
!
```

```
mpls ldp router-id Loopback0
!
```

Additional References for EVPN-VPWS

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Commands List, All Releases

Standards and RFCs

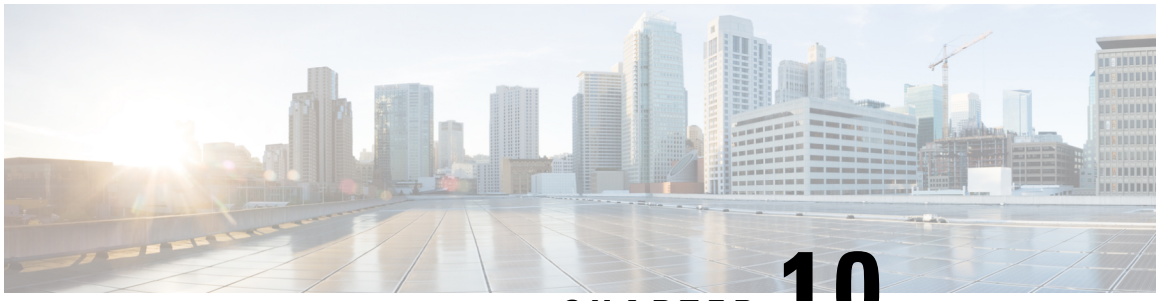
Standard/RFC	Title
RFC 7432	*BGP MPLS-Based Ethernet VPN*
Standard	*VPWS support in EVPN*

MIBs

MIB	MIBs Link
•	—

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html



CHAPTER 10

N:1 PVC Mapping to PWE with Nonunique VPIs

The N:1 PVC Mapping to PseudoWire Emulation (PWE) with Nonunique virtual path identifiers (VPIs) feature maps one or more ATM permanent virtual circuits (PVCs) to a single pseudowire (PW). There are two modes of AAL0 encapsulation, N:1 and 1:1 mapping. In N:1 mapping, multiple unrelated virtual path identifier/virtual channel identifier (VPI/VCI) are carried over a single Multiprotocol Label Switching (MPLS) PW. This is an efficient mapping method because less resources are used from the MPLS network. In 1:1 mapping, a single VPI/VCI is carried over a single MPLS PW. Benefits of this feature include the following:

- Aggregate quality of service (QoS) can be applied to related PVCs.
- Bandwidth is conserved with the reduction in the number of pseudowires that are used.

Restrictions for N:1 PVC Mapping to PWE with Nonunique VPIs

- N:1 permanent virtual circuits (PVC) mapping configuration is supported only on multipoint subinterfaces; it is not supported on main interfaces or point-to-point subinterfaces.
- N:1 PVC mapping mode is not supported on Access Circuit Redundancy subinterfaces.
- Preconfigured PVCs cannot exist on the multipoint subinterface on which you want to configure N:1 PVC mapping.
- An attachment circuit that has been bound to a pseudowire cannot be removed unless all Layer 2 virtual circuits (VCs) have been removed.
- Layer 3 PVCs cannot be configured on N:1 subinterfaces.
- Cell packing values configured under a VC class attached to the PVC, main interface, or subinterface will not be inherited by N:1 PVCs.
- Operation, Administration, and Maintenance (OAM) functionality is not supported on N:1 Layer 2 PVCs. OAM cells coming from the customer edge (CE) network will be treated as normal data traffic and will traverse through the pseudowire.

- Only ATM adaptation layer type 0 (AAL0) encapsulation is supported for N:1 PVCs.
- The service policy configuration can be configured only at the subinterface level for N:1 PVCs.
- ATM N:1 and PVP modes cannot be configured on different subinterfaces that belong to a physical interface.
- You cannot change the ATM interface mode from point-to-point to multipoint or from multipoint to point-to-point.
- If you change a layer 2 ATM interface to a layer 3 ATM interface, traffic will not flow.

Information About N:1 PVC Mapping to PWE with Nonunique VPIs

N:1 PVC Mapping to PWE with Nonunique VPIs Feature Description

To transport ATM cells over Multiprotocol Label Switching (MPLS), a VC is established between the provider edge (PE) routers on both ends of the MPLS backbone. With the N:1 permanent virtual circuit (PVC) Mapping to PseudoWire Emulation (PWE) with Nonunique VPIs feature, multiple PVCs irrespective of their Virtual Path Identifiers (VPIs), are transported over a single pseudowire configured on a subinterface. ("N:1" refers to the number of PVCs transported over one pseudowire). ATM cells are packed together in a single frame and sent over the single pseudowire. The ATM cell header information is packed together with the cell payload on a per-cell basis in the packets so that packets received at the egress end are unpacked and the ATM cells are mapped to the respective PVCs.

In N:1 PVC mapping mode, the device can pack cells only from a single PVC in an MPLS packet to transmit over a pseudowire; cells from multiple PVCs cannot be packed in a single MPLS packet and mapped to a single pseudowire for transmission. However, if a device receives an MPLS packet that is packed with cells from multiple PVCs, then those cells will be unpacked and sent to the respective PVCs.

How to Configure N:1 PVC Mapping to PWE with Nonunique VPIs

Configuring N:1 PVC Mapping to PWE with Nonunique VPIs

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface atm** *slot/subslot/port*
4. **atm mcpt-timers** *timer1 timer2 timer3*
5. **exit**
6. **configure terminal**

7. **interface atm** *slot/subslot/port.subslot* **multipoint**
8. **no ip address**
9. **atm enable-ilmi-trap**
10. **cell-packing** *maxcells* **mcpt-timer** *timer-number*
11. **xconnect** *peer-ipaddress vc-id* **encapsulation mpls**
12. **pvc** *vpi/vci* **l2transport**
13. Repeat Step 12 for the number of PVCs that you want to configure.
14. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface atm** *slot/subslot/port* **Example:** `Device(config)# interface atm 9/1/1`	Enables the ATM interface and enters interface configuration mode.
Step 4	**atm mcpt-timers** *timer1 timer2 timer3* **Example:** `Device(config-if)# atm mcpt-timers 100 200 300`	Sets the Maximum Cell Packing Timeout (MCPT) values in microseconds. • The MCPT timer sets the time for which the device waits for the raw cells (AAL0 encapsulation) to be packed into a single packet for punting to the pseudowire.
Step 5	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode.
Step 6	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 7	**interface atm** *slot/subslot/port.subslot* **multipoint** **Example:** `Device(config)# interface atm 9/1/1.1 multipoint`	Enters subinterface configuration mode and creates a multipoint subinterface on the given port on the specified ATM Shared Port Adapter (SPA).
Step 8	**no ip address** **Example:** `Device(config-subif)# no ip address`	Removes the interface IP address.

	Command or Action	Purpose
Step 9	**atm enable-ilmi-trap** **Example:** `Device(config-subif)# atm enable-ilmi-trap`	Generates an Integrated Local Management Interface (ILMI) atmfVccChange trap when an ATM interface or subinterface is enabled or shut down.
Step 10	**cell-packing** *maxcells* **mcpt-timer** *timer-number* **Example:** `Device(config-subif)# cell-packing 20 mcpt-timer 2`	Enables ATM over MPLS to pack multiple ATM cells into each MPLS packet within the MCPT timing.
Step 11	**xconnect** *peer-ipaddress vc-id* **encapsulation mpls** **Example:** `Device(config-subif)# xconnect 10.1.1.1 100 encapsulation mpls`	(Optional) Enables the attachment circuit and specifies the IP address of the peer, a VC ID, and the data encapsulation method.
Step 12	**pvc** *vpi/vci* **l2transport** **Example:** `Device(config-subif)# pvc 10/100 l2transport`	Assigns a VPI and virtual channel identifier (VCI).
Step 13	Repeat Step 12 for the number of PVCs that you want to configure.	—
Step 14	**end** **Example:** `Device(config-subif)# end`	Exits subinterface configuration mode and returns to privileged EXEC mode.

Configuration Examples for N:1 PVC Mapping to PWE with Nonunique VPIs

Example: Configuring N:1 PVC Mapping to PWE with Nonunique VPIs

The following example shows how to configure the N:1 ATM permanent virtual circuit (PVC) mapping to pseudowires with non unique virtual path identifiers (VPIs):

```
Device> enable
Device# configure terminal
Device(config)# interface atm 0/1/0
Device(config-if)# atm mcpt-timers 500 5000 50000
Device(config-if)# exit
Device# configure terminal
Device(config)# interface atm 0/1/0.1 multipoint
Device(config-subif)# no ip address
Device(config-subif)# atm enable-ilmi-trap
Device(config-subif)# cell packing 20 mcpt-timer 2
Device(config-subif)# xconnect 10.1.1.1 100 encapsulation mpls
Device(config-subif)# pvc 10/100 l2transport
```

```
Device(config-subif)# pvc 11/122 l2transport
Device(config-subif)# pvc 19/231 l2transport
Device(config-subif)# end
```

Verifying the N:1 PVC Mapping to PWE with Nonunique VPIs Configuration

To verify the N:1 PVC Mapping to PWE with Nonunique VPIs Configuration, use the **show mpls l2transport vc** command in user EXEC or privileged EXEC mode.

```
Router# show mpls l2transport vc

Local intf      Local circuit              Dest address    VC ID    Status
------------    -------------------------  --------------  -------  --------
AT0/1/1.1         ATM CELL ATM0/1/1.1         2.2.2.2       100      UP

interface ATM0/0/0.1/1/1/1
atm mcpt-timers 20 30 40

interface ATM0/0/0.1/1/1/1.1 multipoint
no ip address
no atm enable-ilmi-trap
cell-packing 2 mcpt-timer 1
xconnect 2.2.2.2 100 encapsulation mpls
pvc 10/100 l2transport
pvc 20/200 l2transport
pvc 30/300 l2transport
```

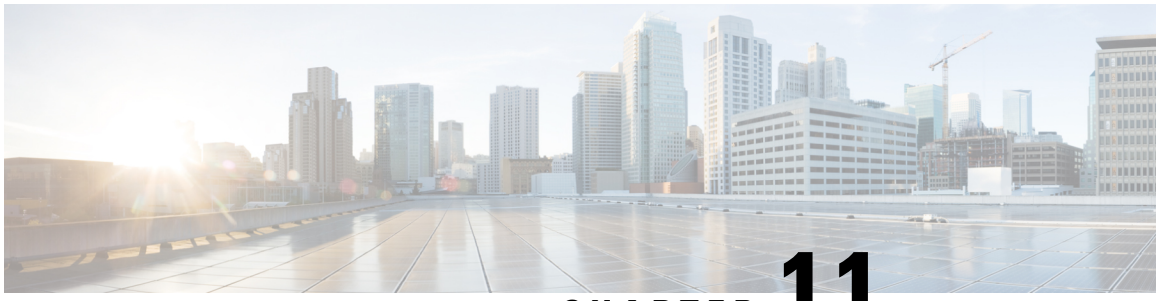
Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Master Command List
ATM commands	Asynchronous Transfer Mode Command Reference

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html



CHAPTER 11

Pseudowire Group Switchover

The Pseudowire Group Switchover feature allows all pseudowires in a group to be quickly switched over to backup pseudowires. This group switchover is triggered by a single “group down” status message received from a remote peer.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for Pseudowire Group Switchover

- The remote provider edge (PE) router must be capable of sending group status messages.
- Label Distribution Protocol (LDP) must be implemented on the network.
- Each xconnect must have a backup pseudowire configured.

Restrictions for Pseudowire Group Switchover

This feature is supported on the following attachment circuits:

- Ethernet VLAN
- Asynchronous Transfer Mode (ATM)
- Circuit Emulation (CEM) over MPLS
- The pseudowire group switch over convergence number increments linearly with thousand virtual circuits taking 16 seconds of convergence time.

Information About Pseudowire Group Switchover

Introduction to Pseudowire Group Switchover

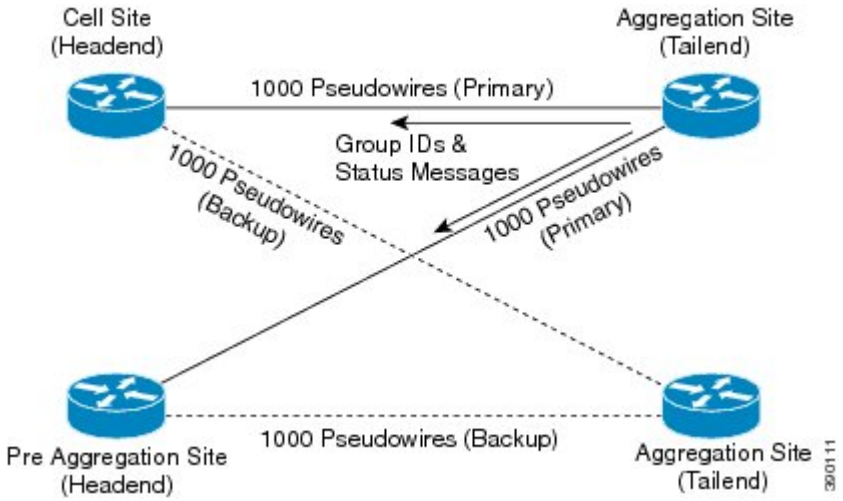
The Pseudowire Group Switchover feature allows you to reduce the switchover time from main pseudowires to backup pseudowires when a fault is encountered. The reduced switchover time is achieved by grouping Label Distribution Protocol (LDP) status messages and internal interprocess communication (IPC) messages.

When the remote peer detects an attachment circuit failure, it sends an LDP status message. When this status message is received, the designated backup pseudowires take over. Packets are then routed through the backup pseudowires.

Pseudowires can be grouped together by assigning a group ID. When an LDP status message is received by a pseudowire group, the entire group switches over, thus reducing switchover time.

Note The Pseudowire Group Switchover feature is enabled by default and cannot be disabled.

Figure 15: Primary and Backup Pseudowire Groups



How to Configure Predictive Switchover

Predictive switchover allows switchovers from a main pseudowire to a backup pseudowire with a remote "standby" status, without waiting for an “up” status from the remote peer.

Predictive switchover is configured by enabling redundancy predictive mode in global configuration mode or xconnect configuration mode.

Configuring Predictive Switchover (Global Configuration Mode)

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **l2vpn**
4. **redundancy predictive enabled**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**l2vpn** **Example:** `Device(config)# l2vpn`	Enters l2vpn configuration mode.
Step 4	**redundancy predictive enabled** **Example:** `Device(config-l2vpn)# redundancy predictive enabled`	Enables redundancy predictive mode. • By default, redundancy predictive mode is disabled.
Step 5	**end** **Example:** `Device(config-l2vpn)# end`	Exits l2vpn configuration mode and returns to privileged EXEC mode.

Configuring Predictive Switchover (Xconnect Configuration Mode)

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **l2vpn xconnect context** *context-name*
4. **redundancy predictive enabled**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**l2vpn xconnect context** *context-name* **Example:** `Device(config)# l2vpn xconnect context con1`	Creates an L2VPN cross-connect context and enters xconnect configuration mode.
Step 4	**redundancy predictive enabled** **Example:** `Device(config-xconnect)# redundancy predictive enabled`	Enables redundancy predictive mode.
Step 5	**end** **Example:** `Device(config-xconnect)# end`	Exits xconnect configuration mode and returns to privileged EXEC mode.

Verifying a Pseudowire Group Switchover Configuration

You can use **show** commands to view information about a pseudowire group switchover configuration.

The following example shows how to display information about Any Transport over MPLS (AToM) virtual circuits (VCs):

```
Device# show l2vpn atom vc destination 2.1.1.2 group remote 6

                                        Service
Interface  Dest Address     VC ID     Type     Name                    Status
---------  ---------------  ----------  ------  ------------------------  ----------
pw100001   2.1.1.2         1234000    p2p      Et1/0.1-1001            UP
```

The following example shows how to display the status of the pseudowire switching point:

```
Device# show l2vpn atom vc destination 2.1.1.2 group remote 6 detail

pseudowire100001 is up, VC status is up PW type: Ethernet
  Create time: 5d20h, last status change time: 5d20h
    Last label FSM state change time: 5d20h
  Destination address: 2.1.1.2 VC ID: 1234000
    Output interface: Et0/0, imposed label stack {2001}
  Preferred path: not configured
  Default path: active
  Next hop: 20.0.0.2
Member of xconnect service Et1/0.1-1001, group right
  Associated member Et1/0.1 is up, status is up
  Interworking type is Ethernet
  Service id: 0x6d000002
Signaling protocol: LDP, peer 2.1.1.2:0 up
  Targeted Hello: 1.1.1.1(LDP Id) -> 2.1.1.2, LDP is UP
  Graceful restart: not configured and not enabled
  Non stop routing: not configured and not enabled
  PWid FEC (128), VC ID: 1234000
  Status TLV support (local/remote) : enabled/supported
    LDP route watch : enabled
    Label/status state machine : established, LruRru
    Local dataplane status received : No fault
    BFD dataplane status received : Not sent
    BFD peer monitor status received : No fault
    Status received from access circuit : No fault
    Status sent to access circuit : No fault
    Status received from pseudowire i/f : No fault
    Status sent to network peer : No fault
    Status received from network peer : No fault
    Adjacency status of remote peer : No fault
Sequencing: receive disabled, send disabled
Bindings
Parameter    Local                          Remote
------------ ------------------------------ ------------------------------
Label        2007                           2001
Group ID     0                              6
Interface
MTU          1500                           1500
Control word on (configured: autosense)     on
PW type      Ethernet                       Ethernet
VCCV CV type 0x12                           0x12
               LSPV [2], BFD/Raw [5]          LSPV [2], BFD/Raw [5]
VCCV CC type 0x07                           0x07
             CW [1], RA [2], TTL [3]        CW [1], RA [2], TTL [3]
Status TLV   enabled                        supported
Dataplane:
  SSM segment/switch IDs: 12309/4115 (used), PWID: 1
Rx Counters
  106563 input transit packets, 9803650 bytes
  0 drops, 0 seq err
Tx Counters
  0 output transit packets, 0 bytes
  0 drops
```

The following example lists the active and standby segment pairs associated with each peer IP address and group identifier:

```
Device# show ssm group

Active              Standby
IP Address       Group ID       Segment/Switch      Segment/Switch
```

```
==========================================================================
2.1.1.2               6            8215/4115           4116/8210
```

The following example displays the number of active and standby segment pairs associated with each peer IP address and group identifier:

```
Device# show ssm group 2.1.1.2 6 summary

IP Address        Group ID      Group Members
=========================================
2.1.1.2               6              1
```

The following example displays the number of pseudowires programmed in the hardware, with grouping information:

```
Device# show platform hardware pp active pw eompls group brief

Brief L2VPN EoMPLS Pseudo Wire Group Info

IP address           Group ID            Count
-----------------------------------------------------
0x47474747           100695488            90
```

Troubleshooting a Pseudowire Group Switchover Configuration

Use the **debug platform software atom brief** command to view information about the following configurations:

- Add Group
- Delete From Group
- Group Switchovers

Note We recommend that you use the **debug platform software atom brief** command only under Cisco Technical Assistance Center (TAC) supervision.

Configuration Examples for Predictive Switchover

Example: Configuring Predictive Switchover (Global Configuration Mode)

```
Device> enable
Device# configure terminal
Device(config)# l2vpn
Device(config-l2vpn)# redundancy predictive enabled
Device(config-l2vpn)# end
```

Example: Configuring Predictive Switchover (Xconnect Configuration Mode)

```
Device> enable
Device# configure terminal
Device(config)# l2vpn xconnect context con1
```

```
Device(config-xconnect)# redundancy predictive enabled
Device(config-xconnect)# end
```

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
MPLS commands	Cisco IOS Multiprotocol Label Switching Command Reference

Standards and RFCs

Standard/RFC	Title
RFC 4447	*Pseudowire Setup and Maintenance Using the Label Distribution Protocol (LDP)*

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

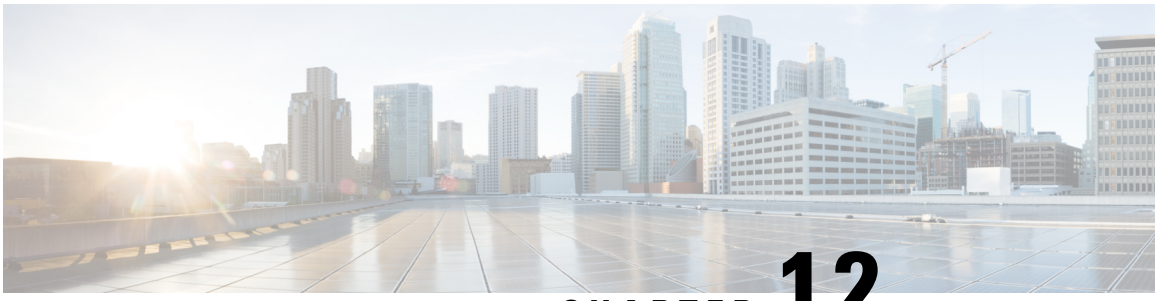
Feature Information for Pseudowire Group Switchover

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 15: Feature Information for Pseudowire Group Switchover

Feature Name	Releases	Feature Information
Pseudowire Group Switchover	Cisco IOS XE Release 3.13.0S	This feature was introduced on the Cisco ASR 920 Routers (ASR-920-12CZ-A, ASR-920-12CZ-D, ASR-920-4SZ-A, ASR-920-4SZ-D).



CHAPTER 12

Configuring Routed Pseudowire and VPLS

Routed Pseudowire and VPLS feature routes Layer 3 traffic and Layer 2 frames for pseudowire connections between provider edge (PE) devices using Virtual Private LAN Services (VPLS) multipoint PE.

Prerequisites for Routed Pseudowire and VPLS

- MTU must be manually configured for MPLS enabled interfaces.

Restrictions for Routed Pseudowire and VPLS

- Maximum number of routed VPLS supported per system is 128.
- Maximum number of pseudowires supported per bridge domain is 62.
- Layer 2 and Layer 3 multicast are *not* supported.
- ACL on the core network is *not* supported.
- PBR is *not* supported.
- MTU check is *not* supported. MTU must be manually configured for MPLS enabled interfaces.
- MPLS is *not* supported on routed VPLS.

Information About Routed Pseudowire and VPLS

Routed Pseudowire and VPLS

Routed Pseudowire and VPLS configuration can route Layer 3 traffic as well as Layer 2 frames for pseudowire connections between provider edge (PE) devices using Virtual Private LAN Services (VPLS) multipoint PE. The ability to route frames to and from these interfaces supports termination of pseudowires into the Layer 3 network (VPN or global) on the same switch, or to the tunnel Layer 3 frames over a Layer 2 tunnel (VPLS).

To configure routing support for a pseudowire, configure the IP address and other Layer 3 features for the Layer 3 domain in interface configuration mode.

Note BFD over BDI is supported with routed VPLS configuration.

How to Configure Routed Pseudowire and VPLS

Assigning IP Addresses For Bridge Domain (BDI)

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface bdi** *bdi-number*
4. **ip address** *ip address subnet mask*
5. **no shut**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**interface bdi** *bdi-number* **Example:** `Router(config)# interface bdi 3000`	Configures the bridge domain interface.
Step 4	**ip address** *ip address subnet mask* **Example:** `Router(config-if)# ip address 24.24.24.24 255.255.255.0`	Specifies the IP address for the bridge domain.
Step 5	**no shut** **Example:** `Router(config-if)# no shutdown`	Enables the bridge domain interface.
Step 6	**end** **Example:** `Router(config-if)# end`	Exits interface configuration mode.

Configuring a VFI on a PE Device

The virtual forwarding interface (VFI) specifies the VPN ID of a Virtual Private LAN Services (VPLS) domain, the addresses of other provider edge (PE) devices in the domain, and the type of tunnel signaling and encapsulation mechanism for each peer.

Note Only Multiprotocol Label Switching (MPLS) encapsulation is supported.

Note You must configure BDI on the bridge domain that has the association with the VFI.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **l2 vfi** *name* **manual**
4. **vpn id** *vpn-id*
5. **neighbor** *remote-router-id vc-id* {**encapsulation** *encapsulation-type* | **pw-class** *pw-name*} [**no-split-horizon**]
6. **bridge-domain** *bd-id*
7. **end**

DETAILED STEPS

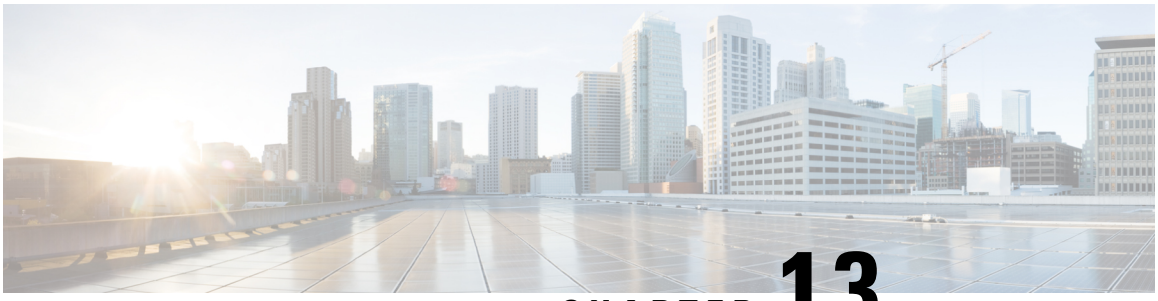
	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**l2 vfi** *name* **manual** **Example:** `Device(config)# l2 vfi vfi110 manual`	Establishes a Layer 2 VPN (L2VPN) virtual forwarding interface (VFI) between two or more separate networks and enters VFI configuration mode.
Step 4	**vpn id** *vpn-id* **Example:** `Device(config-vfi)# vpn id 110`	Configures a VPN ID for a VPLS domain. • The emulated VCs bound to this Layer 2 virtual routing and forwarding (VRF) instance use this VPN ID for signaling.
Step 5	**neighbor** *remote-router-id vc-id* {**encapsulation** *encapsulation-type* | **pw-class** *pw-name*} [**no-split-horizon**] **Example:** `Device(config-vfi)# neighbor 172.16.10.2 4 encapsulation mpls`	Specifies the type of tunnel signaling and encapsulation mechanism for each VPLS peer. **Note** Split horizon is the default configuration to avoid broadcast packet looping and to isolate Layer 2 traffic. Use the **no-split-horizon** keyword to disable split horizon and to configure multiple VCs per spoke into the same VFI.
Step 6	**bridge-domain** *bd-id* **Example:** `Device(config-vfi)# bridge-domain 100`	Specifies a bridge domain.
Step 7	**end** **Example:** `Device(config-vfi)# end`	Exits VFI configuration mode and returns to privileged EXEC mode.

Configuration Examples: Routed Pseudowire and VPLS

Example: Configuring Routed Pseudowire and VPLS

The example configures the IP address on a BDI interface and associates the interface to a VFI.

```
!
interface GigabitEthernet0/0/0
 service instance 3 ethernet
  encapsulation dot1q 3000
  rewrite ingress tag pop 1 symmetric
  bridge-domain 100
!
interface BDI100
 ip address 24.24.24.24 255.255.255.0
 no shut
!
l2 vfi TEST manual
 vpn id 100
 bridge-domain 100
 neighbor 9.9.9.9 encapsulation mpls
!
```



CHAPTER 13

VPLS over Backup Pseudowire

Pseudowire redundancy allows you to detect any failure in the network and reroute the Layer 2 service to another endpoint. The other endpoint can continue to provide this service by providing additional backup pseudowire. This feature provides the ability to recover from a failure of either the remote provider edge (PE) router or the link between the PE and customer edge (CE) routers.

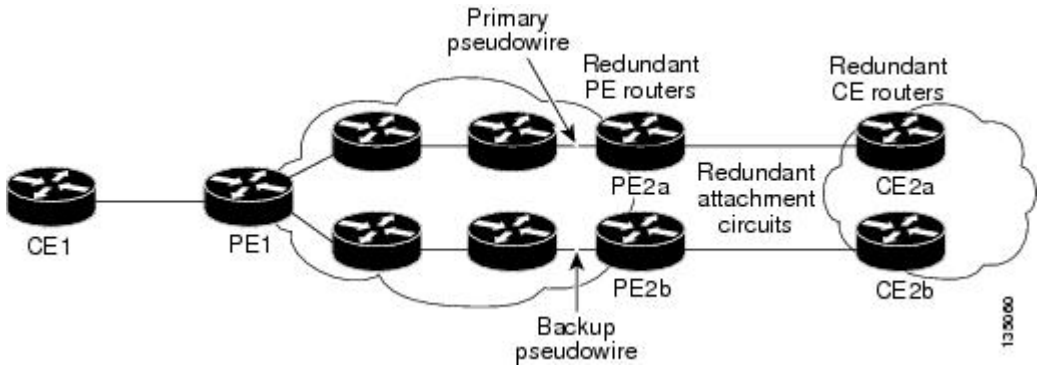
L2VPNs can provide pseudowire resiliency through their routing protocols. When the connectivity between the end-to-end PE routers fails, an alternative path to the directed LDP session and the user data takes over. However, there are some parts of the network in which this rerouting mechanism does not protect against interruptions in service.

RSP3 implementation reuses the EoMPLS configuration to achieve VPLS over the backup pseudowire functionality. The expected convergence in virtual circuit switchover and fallback is approximately 200-300 ms, which increases with scale configuration because only active pseudowire is programmed in hardware.

These are some scenarios in which pseudowire switchover takes place:

- Core link flap
- Access link flap
- Default access interface
- Remote loopback interface flap
- LDP disable or enable
- Control Word change
- VPN ID change within pseudowire configuration
- Cable pull
- Core side interface module reload
- Core side BFD flap (if configured)
- Core side IGP down
- Remote PE or P node reload or crash

Figure 16: Sample Topology for VPLS over Backup Pseudowire Deployment Scenario



Prerequisites for VPLS over Backup Pseudowire

- IGP and LDP should be up and running between peer devices.
- MTU must be manually configured for MPLS enabled interfaces.

Restrictions for VPLS over Backup Pseudowire

- Only one active and one backup pseudowire (PW) for each bridge domain (BD) is supported.
- Hierarchal Virtual Private Lan Service (HVPLS) is not supported.
- VPLS with BGP auto discovery is not supported.
- 1000 active PW with one backup PW for each VPLS session is supported.
- This feature is supported only with the new VPLS configuration model (on all the PE nodes).
- VFIs configured with the old configuration model cannot coexist with the VFIs of the new configuration model on the same BD.
- The member BDI should not be in the same group as the PW under l2vpn xconnect context configuration.
- More than two PW should not be configured in L2VPN context.
- In an L2VPN cross-connect context, the member BDI and the member physical interface cannot be configured at the same time. It leads to error objects.
- The maximum scale for VPLS session is 1000.
- The BDI used for this feature should not be configured with any IP configuration like MPLS IP, DHCP IP,or static IP.

- Routed PW cannot be configured because BDI interface cannot be configured with IP address.

Convergence Time for the VPLS Sessions

Table 16: Convergence Time (in Milliseconds) with One VPLS Session

Packet Size (Bytes)	Convergence Time (approximate)	Type Of Packet
64	213	IP
128	186	IP
256	173	IP
512	170	IP
1028	186	IP
1400	167	IP

Table 17: Convergence Time (in Milliseconds) with Multiple VPLS Session

Number of Virtual Circuits	Scenario	Convergence Time (approximate)
10	Active Down	373.56
	Reoptimization	15.73
100	Active Down	1880
	Reoptimization	517.93

VPLS over Backup Pseudowire Configuration

The following example shows the configuration on provider edge (PE) router 1 having two links to PE router 2 with IP address 209.165.200.225 and PE router 3 with IP address 209.165.200.226:

Configuration on PE router 1:

```
interface GigabitEthernet0/2/3
 no ip address
   negotiation auto
 service instance 1 ethernet
    encapsulation dot1q 1
    rewrite ingress tag pop 1 symmetric
!
bridge-domain 1000
 member GigabitEthernet0/2/3 service-instance 1
!
interface pseudowire10
 encapsulation mpls
 neighbor 209.165.200.225 1000
!
```

```
interface pseudowire20
 encapsulation mpls
 neighbor 209.165.200.226 2000
!
interface BDI1000
 no ip address
!
l2vpn xconnect context VC_1
 member BDI1000
 member pseudowire10 group Grp_1 priority 1
 member pseudowire20 group Grp_1 priority 2
```

Configuration on PE router 2:

```
interface GigabitEthernet0/2/4
 no ip address
 carrier-delay msec 0
 negotiation auto
 service instance 1 ethernet
    encapsulation dot1q 1
    rewrite ingress tag pop 1 symmetric!
bridge-domain 1
 member GigabitEthernet0/2/4 service-instance 1
!
interface pseudowire10
 encapsulation mpls
 neighbor 209.165.200.224 10
!
interface BDI1
 no ip address
!
l2vpn xconnect context VC_1
 member BDI1
 member pseudowire10 group Grp_1 priority 1
```

Configuration on PE router 3:

```
interface GigabitEthernet0/2/0
 no ip address
 carrier-delay msec 0
  negotiation auto
  service instance 1 ethernet
    encapsulation dot1q 1
    rewrite ingress tag pop 1 symmetric
!
bridge-domain 1
 member GigabitEthernet0/2/0 service-instance 1
!
interface pseudowire10
 encapsulation mpls
 neighbor 209.165.200.224 20
!
interface BDI1
 no ip address
!
l2vpn xconnect context VC_1
 member BDI1
 member pseudowire10 group Grp_1 priority 1
```

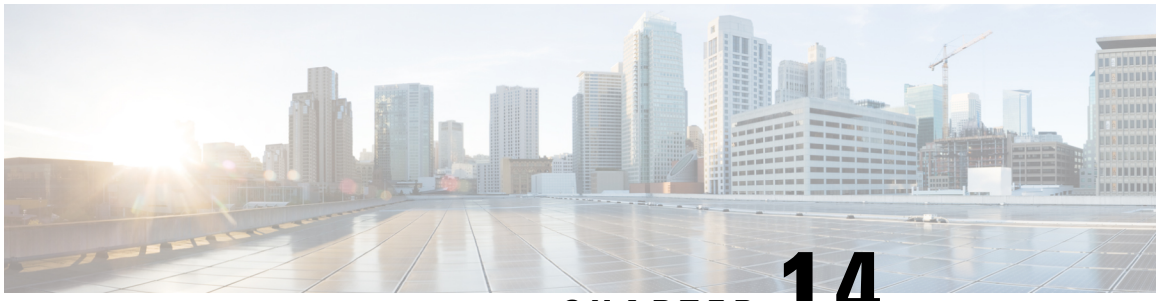
Verify VPLS over Backup Pseudowire Configuration

Use the following commands to verify the VPLS over backup pseudowire configuration on the PE router 1 head node:

```
PE1#show mpls l2transport vc
Local intf     Local circuit              Dest address    VC ID      Status
-------------  -------------------------- --------------- ---------- ----------
BD1000         Eth VLAN 1000              209.165.200.225    1000       UP
BD1000         Eth VLAN 1000              209.165.200.226    2000       STANDBY


PE1#show mpls l2transport vc 1000 detail
Local interface: BD1000 up, line protocol up, Eth VLAN 1000 up
  Interworking type is Ethernet
  Destination address: 209.165.200.225, VC ID: 1000, VC status: up
    Output interface: Gi0/2/5, imposed label stack {24 24}
    Preferred path: not configured
    Default path: active
    Next hop: 192.168.1.2
  Create time: 00:08:46, last status change time: 00:07:14
    Last label FSM state change time: 00:07:12
  Signaling protocol: LDP, peer 209.165.200.225:0 up
    Targeted Hello: 209.165.200.227(LDP Id) -> 209.165.200.225, LDP is UP
    Graceful restart: configured and enabled
    Non stop routing: configured and enabled
    Status TLV support (local/remote)   : enabled/supported
      LDP route watch                   : enabled
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: No fault
      Last BFD dataplane     status rcvd: Not sent
      Last BFD peer monitor  status rcvd: No fault
      Last local AC  circuit status rcvd: No fault
      Last local AC  circuit status sent: No fault
      Last local PW i/f circ status rcvd: No fault
      Last local LDP TLV     status sent: No fault
      Last remote LDP TLV    status rcvd: No fault
      Last remote LDP ADJ    status rcvd: No fault
    MPLS VC labels: local 24, remote 24
    Group ID: local n/a, remote 0
    MTU: local 1500, remote 1500
    Remote interface description:
  Sequencing: receive disabled, send disabled
  Control Word: On (configured: autosense)
  SSO Descriptor: 209.165.200.225/1000, local label: 24
  Dataplane:
    SSM segment/switch IDs: 4186/4180 (used), PWID: 6
  VC statistics:
    transit packet totals: receive 0, send 0
    transit byte totals:   receive 0, send 0
    transit packet drops:  receive 0, seq error 0, send 0


PE1#show mpls l2transport vc 2000 detail
Local interface: BD1000 up, line protocol up, Eth VLAN 1000 up
  Interworking type is Ethernet
  Destination address: 209.165.200.226, VC ID: 2000, VC status: standby
    Output interface: Gi0/2/1, imposed label stack {21 16}
    Preferred path: not configured
    Default path: active
    Next hop: 192.168.3.2
  Create time: 00:08:51, last status change time: 00:08:51
```

```
    Last label FSM state change time: 00:05:40
  Signaling protocol: LDP, peer 209.165.200.226:0 up
    Targeted Hello: 209.165.200.227(LDP Id) -> 209.165.200.226, LDP is UP
    Graceful restart: configured and enabled
    Non stop routing: configured and enabled
    Status TLV support (local/remote)   : enabled/supported
      LDP route watch                   : enabled
      Label/status state machine        : established, LrdRru
      Last local dataplane   status rcvd: No fault
      Last BFD dataplane     status rcvd: Not sent
      Last BFD peer monitor  status rcvd: No fault
      Last local AC  circuit status rcvd: DOWN(standby)
      Last local AC  circuit status sent: No fault
      Last local PW i/f circ status rcvd: No fault
      Last local LDP TLV     status sent: DOWN(standby)
      Last remote LDP TLV    status rcvd: No fault
      Last remote LDP ADJ    status rcvd: No fault
      MPLS VC labels: local 25, remote 16
    Group ID: local n/a, remote 0
    MTU: local 1500, remote 1500
    Remote interface description:
  Sequencing: receive disabled, send disabled
  Control Word: On (configured: autosense)
  SSO Descriptor: 209.165.200.226/2000, local label: 25
  Dataplane:
    SSM segment/switch IDs: 12382/8277 (used), PWID: 7
  VC statistics:
    transit packet totals: receive 0, send 0
    transit byte totals:   receive 0, send 0
    transit packet drops:  receive 0, seq error 0, send 0


PE1#show bridge-domain 1000
Bridge-domain 1000 (3 ports in all)
State: UP                    Mac learning: Enabled
Aging-Timer: 300 second(s)
Maximum address limit: 65534
    BDI1000  (up)
    GigabitEthernet0/2/3 service instance 1
    BDI1000 service instance 1


PE1#show l2vpn service all detail
Legend: St=State    XC St=State in the L2VPN Service      Prio=Priority
        UP=Up       DN=Down             AD=Admin Down     IA=Inactive
        SB=Standby  HS=Hot Standby      RV=Recovering     NH=No Hardware
        m=manually selected

  Interface          Group       Encapsulation                   Prio  St  XC St
  ---------          -----       -------------                   ----  --  -----
VPWS name: VC_1, State: UP
  pw1000             Grp_1       209.165.200.225:1000(MPLS)              1     UP  UP
                                 Local VC label 24
                                 Remote VC label 24

  pw2000             Grp_1       209.165.200.226:2000(MPLS)              2     SB  IA
                                 Local VC label 25
                                 Remote VC label 16

  BD1000                         BD1000:1000(Eth VLAN)           0     UP  UP
                                 Interworking: ethernet


PE1#show l2vpn service all
```

```
Legend: St=State    XC St=State in the L2VPN Service      Prio=Priority
        UP=Up       DN=Down            AD=Admin Down      IA=Inactive
        SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware
        m=manually selected

  Interface          Group       Encapsulation                  Prio  St  XC St
  ---------          -----       -------------                  ----  --  -----
VPWS name: VC_1, State: UP
  pw1000             Grp_1       209.165.200.225:1000(MPLS)            1     UP  UP
  pw2000             Grp_1       209.165.200.226:2000(MPLS)            2     SB  IA
  BD1000                         BD1000:1000(Eth VLAN)          0     UP  UP
```



CHAPTER 14

VPLS Configuration over MPLS-TP

This chapter describes how to configure VPLS over MPLS-TP and includes the following sections:

For more information, see the MPLS Transport Profile.

VPLS over MPLS-TP

The sections below provide an overview of VPLS over MPLS-TP:

Multiprotocol Label Switching Overview

The Multiprotocol Label Switching (MPLS) Transport Profile (TP) enables you to create tunnels that provide the transport network service layer over which IP and MPLS traffic traverse. MPLS-TP tunnels enable a transition from Synchronous Optical Networking (SONET) and Synchronous Digital Hierarchy (SDH) time-division multiplexing (TDM) technologies to packet switching to support services with high bandwidth requirements, such as video.

Virtual Private LAN Services Overview

uses the provider core to join multiple attachment circuits together to simulate a virtual bridge that connects the multiple attachment circuits together. From a customer point of view, there is no topology for VPLS. All of the CE devices appear to connect to a logical bridge emulated by the provider core. See figure below.

VPLS over MPLS-TP Overview

VPLS over MPLS-TP allows you to deploy a multipoint-to-multipoint layer 2 operating environment over an MPLS-TP network for services such as Ethernet connectivity and multicast video.

References

For detailed information about the commands, see:

- Cisco IOS XE 3.5 MPLS Command Reference:
  http://www.cisco.com/en/US/docs/ios/cether/command/reference/ce_book.html
- Master Command Index for Cisco IOS XE Release 3.5:
  http://www.cisco.com/en/US/docs/ios/mcl/allreleasemcl/all_book.html

Configuring VPLS over MPLS-TP

The sections below describe how to configure VPLS over MPLS-TP:

Configuration Guidelines

VPLS over MPLS-TP is only supported on Gigabit Ethernet and Ten Gigabit Ethernet interfaces.

Configuring the MPLS Label Range

You must specify a static range of MPLS labels using the **mpls label range** command with the **static** keyword.

SUMMARY STEPS

1. enable
2. configure terminal
3. mpls label range *minimum-value maximum-value{* **static***minimum-static-value maximum-static-value}*

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	configure terminal **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	mpls label range *minimum-value maximum-value{* **static***minimum-static-value maximum-static-value}* **Example:** `Router(config)# mpls label range 1001 1003 static 10000 25000`	Specifies a static range of MPLS labels

Configuring the Router ID and Global ID

SUMMARY STEPS

1. enable
2. configure terminal
3. mpls tp
4. router-id *node-id*
5. global-id *num*

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	configure terminal **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	mpls tp **Example:** `Router(config)# mpls tp`	Enters MPLS-TP configuration mode, from which you can configure MPLS-TP parameters for the router.
Step 4	router-id *node-id* **Example:** `Router(config-mpls-tp)# router-id 10.10.10.10`	Specifies the default MPLS-TP router ID, which is used as the default source node ID for all MPLS-TP tunnels configured on the router.
Step 5	global-id *num* **Example:** `Router(config-mpls-tp)# global-id 1`	(Optional) Specifies the default global ID used for all endpoints and midpoints. This command makes the router ID globally unique in a multiprovider tunnel. Otherwise, the router ID is only locally meaningful. The global ID is an autonomous system number, which is a controlled number space by which providers can identify each other. The router ID and global ID are also included in fault messages by routers at tunnel midpoints to help isolate the location of faults.

Configuring the Pseudowire Class

When you create the pseudowire class, you specify the parameters of the pseudowire, such as the use of the control word, and preferred path.

SUMMARY STEPS

1. enable

2. configure terminal
3. pseudowire-class *class-name*
4. encapsulation mpls
5. control-word
6. protocol **{l2tpv2 | l2tpv3 | none}***[l2tp-class-name]*
7. preferred-path {interface tunnel tunnel-number | peer {ip-address | host-name}} [disable-fallback]
8. end

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	configure terminal **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	pseudowire-class *class-name* **Example:** `Router(config)# pseudowire-class mpls-tp-class1`	Creates a pseudowire class and enters pseudowire class configuration mode.
Step 4	encapsulation mpls **Example:** `router(config-pw-class)# encapsulation mpls`	Specifies the encapsulation type.
Step 5	control-word **Example:** `Router(config-pw-class)# control-word`	Enables the use of the control word.
Step 6	protocol **{l2tpv2 | l2tpv3 | none}***[l2tp-class-name]* **Example:** `Router(config-pw-class)# protocol none`	Specifies the type of protocol.
Step 7	preferred-path {interface tunnel tunnel-number | peer {ip-address | host-name}} [disable-fallback] **Example:** `Router(config-pw-class)# preferred-path interface tunnel-tp2`	Specifies the tunnel to use as the preferred path.

Step 8	end
	Example:
	`Router(config-pw-class)# end`
	`Router#`
		Exits configuration mode.

Configuring a BFD Template

SUMMARY STEPS

1. enable
2. configure terminal
3. bfd-template single-hop *template-name*
4. interval microseconds **{both** *microseconds* | **min-tx** *microseconds* **min-rx** *microseconds}* **[multiplier** *multiplier-value]*
5. interval **{both** *milliseconds* | **min-tx** *milliseconds* **min-rx** *milliseconds}* **[multiplier** *multiplier-value]*
6. end

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	configure terminal **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	bfd-template single-hop *template-name* **Example:** `Router(config)# bfd-template single-hop bfdtemplate1`	Creates a BFD template and enters BFD configuration mode. The bfd-template command allows you to create a BFD template and enters BFD configuration mode. The template can be used to specify a set of BFD interval values. You can then invoke the BFD template when you set up the MPLS–TP tunnel.
Step 4	interval microseconds **{both** *microseconds* | **min-tx** *microseconds* **min-rx** *microseconds}* **[multiplier** *multiplier-value]* **Example:** `Router(config-bfd)# interval microseconds both 3300 multiplier 3`	Configures the transmit and receive intervals in microseconds between BFD packets, and specifies the number of consecutive BFD control packets that must be missed from a BFD peer before BFD declares that a peer is unavailable.
Step 5	interval **{both** *milliseconds* | **min-tx** *milliseconds* **min-rx** *milliseconds}* **[multiplier** *multiplier-value]* **Example:** `Router(config-bfd)# interval both 120 multiplier 3`	Configures the transmit and receive intervals in milliseconds between BFD packets, and specifies the number of consecutive BFD control packets that must be missed from a BFD peer before BFD declares that a peer is unavailable.
Step 6	end **Example:**	Exits configuration mode.

	Command or Action	Purpose
	`Router(config-bfd)# end` `Router#`	

Configuring the MPLS-TP Tunnel

On the endpoint routers, create an MPLS TP tunnel and configure its parameters. See the **interface tunnel-tp** command for information on the parameters.

SUMMARY STEPS

1. enable
2. configure terminal
3. interface tunnel-tp *number*
4. description tunnel-description
5. tp tunnel-name *name*
6. tp source *node-id [global-id num]*
7. tp destination *node-id [[* **tunnel-tp***num]* **global-id** *num]*
8. bfd *bfd-template*
9. working-lsp
10. in-label *num*
11. out-label *num* out-link *num*
12. exit
13. protect-lsp
14. in-label *num*
15. out-label *num* out-link *num*
16. exit

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	configure terminal **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	interface tunnel-tp *number* **Example:** `Router(config)# interface tunnel-tp 2`	Enters tunnel interface configuration mode. Tunnel numbers from 0 to 999 are supported.
Step 4	description tunnel-description **Example:**	(Optional) Specifies a tunnel description.

	Command or Action	Purpose
	`Router(config-if)# description headend tunnel`	
Step 5	tp tunnel-name *name* **Example:** `Router(config-if)# tp tunnel-name tunnel22`	Specifies the name of the MPLS-TP tunnel. The TP tunnel name is displayed in the show mpls tp tunnel command output. This command is useful for consistently identifying the tunnel at all endpoints and midpoints.
Step 6	tp source *node-id [global-id num]* **Example:** `Router(config-if)# tp source 10.10.11.11 global-id 10`	(Optional) Specifies the tunnel source and endpoint. This command is and not typically used, because the global router ID and global ID can be used to identify the tunnel source at the endpoint. All tunnels on the router generally use the same (globally specified) source information.
Step 7	tp destination *node-id [[* **tunnel-tp***num]* **global-id** *num]* **Example:** `Router(config-if)# tp destination 10.10.10.10`	Specifies the destination node of the tunnel.
Step 8	bfd *bfd-template* **Example:** `Router(config-if)# bfd template1`	Specifies the BFD template.
Step 9	working-lsp **Example:** `Router(config-if)# working-lsp`	Specifies a working LSP, also known as the primary LSP. This LSP is used to route traffic. This command enters working LSP interface configuration mode (config-if-working).
Step 10	in-label *num* **Example:** `Router(config-if-working)# in-label 10000`	Specifies the in label.
Step 11	out-label *num* out-link *num* **Example:** `Router(config-if-working)# out-label 10000 out-link 1`	Specifies the out label and out link.
Step 12	exit **Example:** `Router(config-if-working)# exit`	Exits from working LSP interface configuration mode.
Step 13	protect-lsp **Example:** `Router(config-if)# protect-lsp`	Specifies a backup for a working LSP. If the working LSP fails, traffic is switched to the protect LSP until the working LSP is restored, at which time forwarding reverts back to the working LSP. This command enters protect LSP interface configuration mode (config-if-protect).
Step 14	in-label *num* **Example:** `Router(config-if-protect)# in-label 10001`	Specifies the in label.

	Command or Action	Purpose
Step 15	out-label *num* out-link *num* **Example:** `Router(config-if-protect)# out-label 10001 out-link 2`	Specifies the out label and out link.
Step 16	exit **Example:** `Router(config-if-protect)# exit`	Exits from protect LSP interface configuration mode.

Configuring MPLS-TP Links and Physical Interfaces

MPLS-TP link numbers may be assigned to physical interfaces only. Bundled interfaces and virtual interfaces are not supported for MPLS-TP link numbers.

The sections below describe how to configure physical interfaces for a VPLS over MPLS-TP link.

Configuring an Output Interface

SUMMARY STEPS

1. enable
2. configure terminal
3. interface *type/num*
4. no ip address
5. negotiation auto
6. mpls tp link *link-num* {**ipv4** *ip-address* | **tx-mac** *mac-address}*
7. exit
8. exit
9. show mpls tp link-numbers

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable **Example:** `Router> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	configure terminal **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	interface *type/num* **Example:** `Router(config)# interface gigabitEthernet 1/0`	Specifies the interface and enters interface configuration mode.

	Command or Action	Purpose
Step 4	no ip address **Example:** `Router(config-if)# no ip address`	Specifies that there is no IP address assigned to the interface.
Step 5	negotiation auto **Example:** `Router(config-if)# negotiation auto`	Enables the autonegotiation protocol to configure the speed, duplex, and automatic flow control of the Gigabit Ethernet interface.
Step 6	mpls tp link *link-num* {**ipv4** *ip-address* | **tx-mac** *mac-address}* **Example:** `Router(config-if)# mpls tp link 1 ipv4 10.0.0.2`	Associates an MPLS-TP link number with a physical interface and next-hop node. On point-to-point interfaces or Ethernet interfaces designated as point-to-point using the medium p2p command, the next-hop can be implicit, so the mpls tp link command just associates a link number to the interface. Multiple tunnels and LSPs can refer to the MPLS-TP link to indicate they are traversing that interface. You can move the MPLS-TP link from one interface to another without reconfiguring all the MPLS-TP tunnels and LSPs that refer to the link. Link numbers a must be unique on the router or node.
Step 7	exit **Example:** `Router(config-if)# exit`	Exits interface configuration mode.
Step 8	exit **Example:** `Router(config)# exit`	Exits global configuration mode.
Step 9	show mpls tp link-numbers **Example:** `Router# show mpls tp link-numbers`	Displays the configured links.

Configuring an Access Interface

SUMMARY STEPS

1. enable
2. configure terminal
3. interface *type/num*
4. no ip address
5. negotiation auto
6. service instance *id service-type*
7. encapsulation dot1q *vlan-id* second-dot1q {any | *vlan-id* | *vlan-id-vlan-id[,vlan-id-vlan-id]}*

8. bridge-domain *vlan-id* **[access | dot1q** *[tag]* | **dot1q-tunnel] [broadcast] [ignore-bpdu-pid] [pvst-tlv***CE-vlan]* **[increment] [lan-fcs] [split-horizon]**
9. exit

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	configure terminal **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	interface *type/num* **Example:** `Router(config)# interface gigabitethernet 1/0`	Specifies the interface and enters interface configuration mode.
Step 4	no ip address **Example:** `Router(config-if)# no ip address`	Specifies that there is no IP address assigned to the interface.
Step 5	negotiation auto **Example:** `Router(config-if)# negotiation auto`	Enables the autonegotiation protocol to configure the speed, duplex, and automatic flow control of the Gigabit Ethernet interface.
Step 6	service instance *id service-type* **Example:** `Router(config)# service instance 1 ethernet`	Configures an Ethernet service instance.
Step 7	encapsulation dot1q *vlan-id* second-dot1q {any | *vlan-id* | *vlan-id-vlan-id[,vlan-id-vlan-id]}* **Example:** `Router(config-if)# encapsulation dot1q 2`	Enables IEEE 802.1Q encapsulation of traffic on a specified subinterface in a VLAN.
Step 8	bridge-domain *vlan-id* **[access | dot1q** *[tag]* | **dot1q-tunnel] [broadcast] [ignore-bpdu-pid] [pvst-tlv***CE-vlan]* **[increment] [lan-fcs] [split-horizon]** **Example:** `Router(config-if)# bridge-domain 1000`	Places the interface in the same bridge domain as the VFI interface.
Step 9	exit **Example:** `Router(config-if)# exit`	Exits interface configuration mode.

Configuring the VFI in the PE

The virtual switch instance (VFI) specifies the VPN ID of a VPLS domain, the addresses of other PE routers in this domain, and the type of tunnel signaling and encapsulation mechanism for each peer. (This is where you create the VSI and associated VCs.) Configure a VFI as follows:

Note Only MPLS encapsulation is supported.

SUMMARY STEPS

1. l2 vfi name manual
2. vpn id *vpn-id*
3. bridge-domain *vlan-id* **[access | dot1q** *[tag]* | **dot1q-tunnel] [broadcast] [ignore-bpdu-pid] [pvst-tlv** *CE-vlan]* **[increment] [lan-fcs] [split-horizon]**
4. neighbor *remote router id [vc-id-value]* {encapsulation mpls}**[no-split-horizon]**
5. shutdown

DETAILED STEPS

	Command or Action	Purpose
Step 1	l2 vfi name manual **Example:** `Router(config)# l2 vfi vfi17 manual`	Enables the Layer 2 VFI manual configuration mode.
Step 2	vpn id *vpn-id* **Example:** `Router(config-vfi)# vpn id 1000`	Configures a VPN ID for a VPLS domain. The emulated VCs bound to this Layer 2 VRF use this VPN ID for signaling.
Step 3	bridge-domain *vlan-id* **[access | dot1q** *[tag]* | **dot1q-tunnel] [broadcast] [ignore-bpdu-pid] [pvst-tlv** *CE-vlan]* **[increment] [lan-fcs] [split-horizon]** **Example:** `Router(config-vfi)# bridge-domain 1000`	Places the VFI in the same bridge domain as the access interface.
Step 4	neighbor *remote router id [vc-id-value]* {encapsulation mpls}**[no-split-horizon]** **Example:** `Router(config-vfi)# neighbor 1.5.1.1 101 encapsulation mpls`	Specifies the remote peering router ID and the tunnel encapsulation type or the pseudo wire property to be used to set up the emulated VC. **Note** Split horizon is the default configuration to avoid broadcast packet looping and to isolate Layer 2 traffic. Use the no-split-horizon keyword to disable split horizon and to configure multiple VCs per spoke into the same VFI. **Note** The optional VC ID value identifies the emulated VC between a pair of peering PE routers.

	Command or Action	Purpose
Step 5	shutdown **Example:** `Router(config-vfi)# shutdown`	Disconnects all emulated VCs previously established under the Layer 2 VFI and prevents the establishment of new attachment circuits. **Note** It does not prevent the establishment of new attachment circuits configured with the Layer 2 VFI using CLI.

Configuring a Virtual Loopback Interface

This task explains how to configure a basic loopback interface.

The IP address of a loopback interface must be unique across all routers on the network. It must not be used by another interface on the router, and it must not be used by an interface on any other router on the network.

SUMMARY STEPS

1. **configure terminal**
2. **interface loopback** *interface-path-id*
3. **ipv4 address** *ip-address*
4. **end**
5. **show interfaces** *type interface-path-id*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 2	**interface loopback** *interface-path-id* **Example:** `Router#(config)# interface Loopback 3`	Enters interface configuration mode and names the new loopback interface.
Step 3	**ipv4 address** *ip-address* **Example:** `Router(config-if)# ipv4 address 172.18.189.38`	Assigns an IP address and subnet mask to the virtual loopback interface using the ipv4 address configuration command.

Step 4	**end**
	Example:
	`Router(config-if)# end`
		Saves configuration changes. When you issue the end command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)?`
		`[cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.

	Command or Action	Purpose
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. **Note** Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 5	**show interfaces** *type interface-path-id* **Example:** `router# show interfaces Loopback 3`	(Optional) Displays the configuration of the loopback interface.

Verifying the Configuration

You can use the following commands to verify your configuration:

- **show mpls l2transport vc**—Displays information about Any Transport over MPLS (AToM) virtual circuits (VCs) and static pseudowires that have been enabled to route Layer 2 packets on the router.
- **show mpls tp**—Displays information about Multiprotocol Label Switching (MPLS) transport profile (TP) tunnels.
- **show bfd summary**—Displays summary information for Bidirectional Forwarding Protocol (BFD).
- **show xconnect**—Displays information about xconnect attachment circuits and pseudowires.

You can use the following commands to debug your configuration:

- **debug mpls tp all**—Debug for all MPLS-TP information.
- **debug mpls tp cli**—Debug for MPLS-TP CLI
- **debug mpls tp error**—Debug for MPLS-TP errors
- **debug mpls tp event**—Debug for MPLS events
- **debug mpls tp fault-oam**—Debug for Fault-OAM
- **debug mpls tp ha**—Debug for High availability
- **debug mpls tp init**—Debug for MPLS-TP initialization
- **debug mpls tp link-management**—Debug for link management
- **debug mpls tp link-num**—Debug for link number database
- **debug mpls tp lsp-db**—Debug for LSP database
- **debug mpls tp lsp-ep**—Debug for endpoint LSP configuration and operation

- **debug mpls tp lsp-mp**—Debug for midpoint LSP configuration and operation
- **debug mpls tp mem**—Debug for memory allocation and usage
- **debug mpls tp tun-db**—Debug for the tunnel database
- **debug mpls tp tunnel**—Debug for tunnel configuration and operation

Configuration Examples

PE Configuration

```
!
mpls label range 1001 4000 static 16 1000
mpls tp
 router-id 10.10.10.10
!
bfd-template single-hop testbfd
interval microseconds min-tx 50000 min-rx 50000 multiplier 3
!
! Output link
interface GigabitEthernet0/0/0
 no ip address
 negotiation auto
 mpls tp link 2 tx-mac 88f0.7768.2300
!

! Output link
interface GigabitEthernet0/2/0
 no ip address
 negotiation auto
 mpls tp link 1 tx-mac 88f0.7768.2310
!
!
interface Tunnel-tp1
ip unnumbered Loopback0
 no keepalive
 tp source 10.10.10.10 global-id 0
 tp destination 192.168.1.1 global-id 0
 bfd testbfd
 working-lsp
  out-label 100 out-link 1
  in-label 200
  lsp-number 0
 protect-lsp
  out-label 300 out-link 2
  in-label 400
  lsp-number 102
!
!
pseudowire-class myclass
 encapsulation mpls
 preferred-path interface Tunnel-tp1
!
!
!VFI definition
l2 vfi VPLS manual
 vpn id 1000
 bridge-domain 1000
 neighbor 192.168.1.1 pw-class myclass
```

```
!
!
interface Loopback0
 ip address 10.10.10.10 255.255.255.255
!
! Access interface
interface GigabitEthernet0/1/0
 no ip address
 negotiation auto
 service instance 1 ethernet
  encapsulation dot1q 2
  bridge-domain 1000
!
```

P Configuration (Midpoint)

```
!
interface loopback 0
ip address 9.9.9.9 255.255.255.255
!
mpls label range 1001 4000 static 16 1000
mpls t
router-id 9.9.9.9
!
mpls tp lsp source 10.10.10.10 tunnel-tp 1 lsp working destination 192.168.1.1 tunnel-tp 1
 forward-lsp
  in-label 100 out-label 300 out-link 1
reverse-lsp
  in-label 400 out-label 200 out-link 2
!
out-link 1 connected to 192.168.1.1
out-link 2 connected to 10.10.10.10
```

Feature Information for VPLS Configuration over MPLS-TP

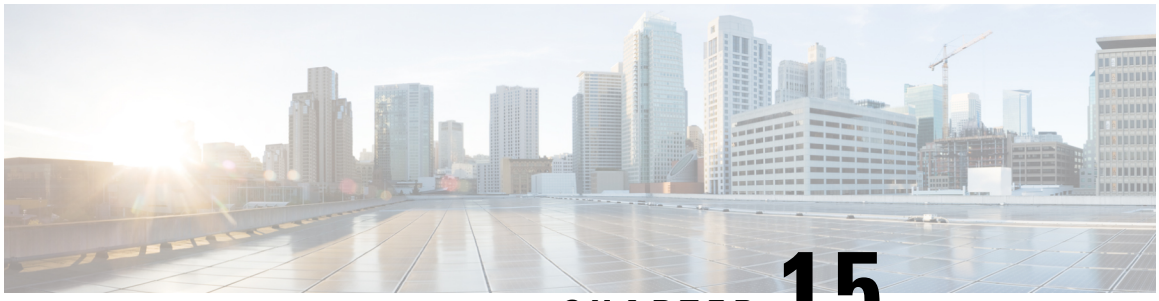
The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 18: Feature Information for VPLS Configuration over MPLS-TP

Feature Name	Release	Feature Information
VPLS Configuration over MPLS-TP	IOS XE 3.5	This feature was introduced on the Cisco RSP1 Module in this release.
VPLS Configuration over MPLS-TP	IOS XE 3.13	This feature was introduced on the Cisco RSP2 Module in this release.
VPLS Configuration over MPLS-TP	IOS XE 3.16	This feature was introduced on the Cisco RSP3 Module in this release.

Feature Name	Release	Feature Information
VPLS Configuration over MPLS-TP	IOS XE 3.13	This feature was introduced on the Cisco ASR 920 Series Aggregation Services Router.



CHAPTER 15

Pseudowire Stitching

Pseudowire stitching is a technique where a pair of independent pseudowires are configured in such a way that they behave like a single point to point pseudowire. It is also called as multi-segment pseudowire (MS-PW).

Pseudowire stitching can be achieved using cross-connect.

Benefits of Pseudowire Stitching

Pseudowire stitching is useful in scenarios where a large network needs to be divided into small pieces, for example, core and metro side, each part of the network will be stitched to achieve end-to-end seamless connectivity.

Configuring Pseudowire Stitching

Below is an example with three nodes connected:

Router IDs are:

- R1 - 1.1.1.1
- R2 - 2.2.2.2
- R3 - 3.3.3.3

Configuration on R1 node:

```
interface GigabitEthernet0/1/0
 no ip address
 negotiation auto
 service instance 1 ethernet
  encapsulation dot1q 1
  xconnect 2.2.2.2 100 encapsulation mpls
 !
```

Configuration on R2 node: (Stitching point)

```
l2vpn xconnect context PW
 member 1.1.1.1 100 encapsulation mpls
 member 3.3.3.3 100 encapsulation mpls
```

Configuration on R3 node:

```
interface GigabitEthernet0/1/0
 no ip address
 negotiation auto
 service instance 1 ethernet
  encapsulation dot1q 1
  xconnect 2.2.2.2 100 encapsulation mpls
 !
```

Verifying Pseudowire Stitching

```
R2#show mpls l2transport vc

Local intf     Local circuit              Dest address    VC ID      Status
-------------  -------------------------- --------------- ---------- ----------
pw100010       3.3.3.3 100                1.1.1.1         100        UP
pw100009       1.1.1.1 100                3.3.3.3         100        UP
```