Implementing Multipoint Layer 2 Services

This module provides the conceptual and configuration information for Multipoint Layer 2 Bridging Services, also called Virtual Private LAN Services (VPLS).

Note VPLS supports Layer 2 VPN technology and provides transparent multipoint Layer 2 connectivity for customers. This approach enables service providers to host a multitude of new services such as broadcast TV and Layer 2 VPNs.

For Point to Point Layer 2 Services, see *Implementing Point to Point Layer 2 Services* chapter.

For descriptions of the commands listed in this module, see the "Related Documents" section.

Feature History for Implementing Multipoint Layer 2 Services

Release	Modification
Release 3.7.2	This feature was introduced.
Release 3.9.0	These features were added: • Blocking unknown unicast flooding. • Disabling MAC flush. • Multiple Spanning Tree Access Gateway • Scale enhancements were introduced. See Table 1 for more information on scale enhancements.
Release 3.9.1	Support for VPLS with BGP Autodiscovery and LDP Signaling was added.
Release 4.0.1	Support was added for the following features: • Dynamic ARP Inspection • IP SourceGuard • MAC Address Security

Release	Modification
Release 4.1.0	Support was added for these VPLS features on the ASR 9000 SIP-700 line card: • MAC learning and forwarding. • MAC address aging support • MAC Limiting • Split Horizon Group • MAC address Withdrawal • Flooding of unknown unicast, broadcast and multicast packets • Access pseudowire • H-VPLS PW-access • PW redundancy Support was added for the G.8032 Ethernet Ring Protection feature.
Release 4.2.1	Support was added for Flow Aware Transport (FAT) Pseudowire feature.
Release 4.3.0	Support was added for these features: • Pseudowire Headend (PWHE) • Scale enhancements on ASR 9000 Enhanced Ethernet line card: • Support for 128000 pseudowires within VPWS and VPLS • Support for 128000 pseudowires across VPLS and VPWS instances • Support for upto 512 pseudowires in a bridge • Support for 128000 bundle attachment circuits • Support for 128000 VLANs • L2VPN over GRE
Release 4.3.1	Support was added for: • VC type 4 in VPLS with BGP Autodiscovery • IPv6 support for PWHE

Release	Modification
Release 5.1.0	Support was added for Multipoint Layer 2 Services Label Switched Multicast feature.
Release 5.1.1	Support was added for: • Pseudowire Headend PW-Ether sub-interfaces (VC Type 5) and Pseudowire Headend PW-IW interworking interfaces (VC Type 11) • LFA over Pseudowire Headend.
Release 6.1.2	Support was added for: • Service Path Preference for L2VPN • L2VPN Route Policy
Release 6.6.1	The MAC security recovery feature was introduced.
Release 7.4.1	From this release onwards, we'll deprecate the Multipoint Layer 2 Services Label Switched Multicast feature.

Prerequisites for Implementing Multipoint Layer 2 Services

Before configuring Multipoint Layer 2 Services, ensure that these tasks and conditions are met:

- You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command.

  If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.

- Configure IP routing in the core so that the provider edge (PE) routers can reach each other through IP.
- Configure a loopback interface to originate and terminate Layer 2 traffic. Make sure that the PE routers can access the other router's loopback interface.

Note The loopback interface is not needed in all cases. For example, tunnel selection does not need a loopback interface when Multipoint Layer 2 Services are directly mapped to a TE tunnel.

- Configure MPLS and Label Distribution Protocol (LDP) in the core so that a label switched path (LSP) exists between the PE routers.

Information About Implementing Multipoint Layer 2 Services

To implement Multipoint Layer 2 Services, you should understand these concepts:

Multipoint Layer 2 Services Overview

Multipoint Layer 2 Services enable geographically separated local-area network (LAN) segments to be interconnected as a single bridged domain over an MPLS network. The full functions of the traditional LAN such as MAC address learning, aging, and switching are emulated across all the remotely connected LAN segments that are part of a single bridged domain.

Some of the components present in a Multipoint Layer 2 Services network are described in these sections.

Note Multipoint Layer 2 services are also called as Virtual Private LAN Services.

Bridge Domain

The native bridge domain refers to a Layer 2 broadcast domain consisting of a set of physical or virtual ports (including VFI). Data frames are switched within a bridge domain based on the destination MAC address. Multicast, broadcast, and unknown destination unicast frames are flooded within the bridge domain. In addition, the source MAC address learning is performed on all incoming frames on a bridge domain. A learned address is aged out. Incoming frames are mapped to a bridge domain, based on either the ingress port or a combination of both an ingress port and a MAC header field.

By default, split horizon is enabled for pseudowires under the same VFI. However, in the default configuration, split horizon is not enabled on the attachment circuits (interfaces or pseudowires).

Flood Optimization

A Cisco ASR 9000 Series Router, while bridging traffic in a bridge domain, minimizes the amount of traffic that floods unnecessarily. The Flood Optimization feature accomplishes this functionality. However, in certain failure recovery scenarios, extra flooding is actually desirable in order to prevent traffic loss. Traffic loss occurs during a temporary interval when one of the bridge port links becomes inactive, and a standby link replaces it.

In some configurations, optimizations to minimize traffic flooding is achieved at the expense of traffic loss during the short interval in which one of the bridge's links fails, and a standby link replaces it. Therefore, Flood Optimization can be configured in different modes to specify a particular flooding behavior suitable for your configuration.

These flood optimization modes can be configured:

Bandwidth Optimization Mode

Flooded traffic is sent only to the line cards on which a bridge port or pseudowire that is attached to the bridge domain resides. This is the default mode.

Convergence Mode

Flooded traffic is sent to all line cards in the system. Traffic is flooded regardless of whether they have a bridge port or a pseudowire that is attached to the bridge domain. If there are multiple Equal Cost MPLS Paths (ECMPs) attached to that bridge domain, traffic is flooded to all ECMPs.

The purpose of Convergence Mode is to ensure that an absolute minimum amount of traffic is lost during the short interval of a bridge link change due to a failure.

TE FRR Optimized Mode

The Traffic Engineering Fast Reroute (TE FRR) Optimized Mode is similar to the Bandwidth Optimized Mode, except for the flooding behavior with respect to any TE FRR pseudowires attached to the bridge domain. In TE FRR Optimized Mode, traffic is flooded to both the primary and backup FRR interfaces. This mode is used to minimize traffic loss during an FRR failover, thus ensuring that the bridge traffic complies with the FRR recovery time constraints.

Dynamic ARP Inspection

Dynamic ARP Inspection (DAI) is a method of providing protection against address resolution protocol (ARP) spoofing attacks. It intercepts, logs, and discards ARP packets with invalid IP-to-MAC address bindings. This capability protects the network from certain man-in-the-middle attacks. The DAI feature is disabled by default.

ARP enables IP communication within a Layer 2 broadcast domain by mapping an IP address to a MAC address. Spoofing attacks occur because ARP allows a response from a host even when an ARP request is not actually received. After an attack occurs, all traffic, from the device under attack, first flows through the attacker's system, and then to the router, switch, or the host. An ARP spoofing attack affects the devices connected to your Layer 2 network by sending false information to the ARP caches of the devices connected to the subnet. The sending of false information to an ARP cache is known as ARP cache poisoning.

The Dynamic ARP Inspection feature ensures that only valid ARP requests and responses are relayed. There are two types of ARP inspection:

- Mandatory inspection—The sender’s MAC address, IPv4 address, receiving bridge port XID and bridge are checked.
- Optional inspection—The following items are validated:
  - Source MAC: The sender’s and source MACs are checked. The check is performed on all ARP or RARP packets.
  - Destination MAC: The target and destination MACs are checked. The check is performed on all Reply or Reply Reverse packets.
  - IPv4 Address: For ARP requests, a check is performed to verify if the sender’s IPv4 address is 0.0.0.0, a multicast address or a broadcast address. For ARP Reply and ARP Reply Reverse, a check is performed to verify if the target IPv4 address is 0.0.0.0, a multicast address or a broadcast address. This check is performed on Request, Reply and Reply Reverse packets.

Note The DAI feature is supported on attachment circuits and EFPs. Currently, the DAI feature is not supported on pseudowires.

IP Source Guard

IP source guard (IPSG) is a security feature that filters traffic based on the DHCP snooping binding database and on manually configured IP source bindings in order to restrict IP traffic on non-routed Layer 2 interfaces.

The IPSG feature provides source IP address filtering on a Layer 2 port, to prevent a malicious hosts from manipulating a legitimate host by assuming the legitimate host's IP address. This feature uses dynamic DHCP snooping and static IP source binding to match IP addresses to hosts.

Initially, all IP traffic, except for DHCP packets, on the EFP configured for IPSG is blocked. After a client receives an IP address from the DHCP server, or after static IP source binding is configured by the administrator, all traffic with that IP source address is permitted from that client. Traffic from other hosts is denied. This filtering limits a host's ability to attack the network by claiming a neighbor host's IP address.

Note The IPSG feature is supported on attachment circuits and EFPs. Currently, the IPSG feature is not supported on pseudowires.

Pseudowires

A pseudowire is a point-to-point connection between pairs of PE routers. Its primary function is to emulate services like Ethernet over an underlying core MPLS network through encapsulation into a common MPLS format. By encapsulating services into a common MPLS format, a pseudowire allows carriers to converge their services to an MPLS network.

The following scale enhancements are applicable to ASR 9000 Enhanced Ethernet line card:

- Support for 128000 pseudowires within VPWS and VPLS
- Support for 128000 pseudowires across VPLS and VPWS instances
- Support for upto 512 pseudowires in a bridge

Note This scale enhancement is supported in hardware configurations where RSP3 and ASR 9000 Enhanced Ethernet line cards are used. However, these enhancements are not applicable to the RSP2, ASR 9000 Ethernet Line Card and Cisco ASR 9000 Series SPA Interface Processor-700 line cards.

DHCP Snooping over Pseudowire

The Cisco ASR 9000 Series Routers provide the ability to perform DHCP snooping, where the DHCP server is reachable on a pseudowire. The Pseudowire is considered as a trusted interface.

The dhcp ipv4 snoop profile {*dhcp-snooping-profile1*} command is provided under the bridge domain to enable DHCP snooping on a bridge and to attach a DHCP snooping profile to the bridge.

Virtual Forwarding Instance

VPLS is based on the characteristic of virtual forwarding instance (VFI). A VFI is a virtual bridge port that is capable of performing native bridging functions, such as forwarding, based on the destination MAC address, source MAC address learning and aging, and so forth.

A VFI is created on the PE router for each VPLS instance. The PE routers make packet-forwarding decisions by looking up the VFI of a particular VPLS instance. The VFI acts like a virtual bridge for a given VPLS instance. More than one attachment circuit belonging to a given VPLS are connected to the VFI. The PE router establishes emulated VCs to all the other PE routers in that VPLS instance and attaches these emulated VCs to the VFI. Packet forwarding decisions are based on the data structures maintained in the VFI.

VPLS for an MPLS-based Provider Core

VPLS is a multipoint Layer 2 VPN technology that connects two or more customer devices using bridging techniques. A bridge domain, which is the building block for multipoint bridging, is present on each of the PE routers. The access connections to the bridge domain on a PE router are called attachment circuits. The attachment circuits can be a set of physical ports, virtual ports, or both that are connected to the bridge at each PE device in the network.

After provisioning attachment circuits, neighbor relationships across the MPLS network for this specific instance are established through a set of manual commands identifying the end PEs. When the neighbor association is complete, a full mesh of pseudowires is established among the network-facing provider edge devices, which is a gateway between the MPLS core and the customer domain.

The MPLS/IP provider core simulates a virtual bridge that connects the multiple attachment circuits on each of the PE devices together to form a single broadcast domain. This also requires all of the PE routers that are participating in a VPLS instance to form emulated virtual circuits (VCs) among them.

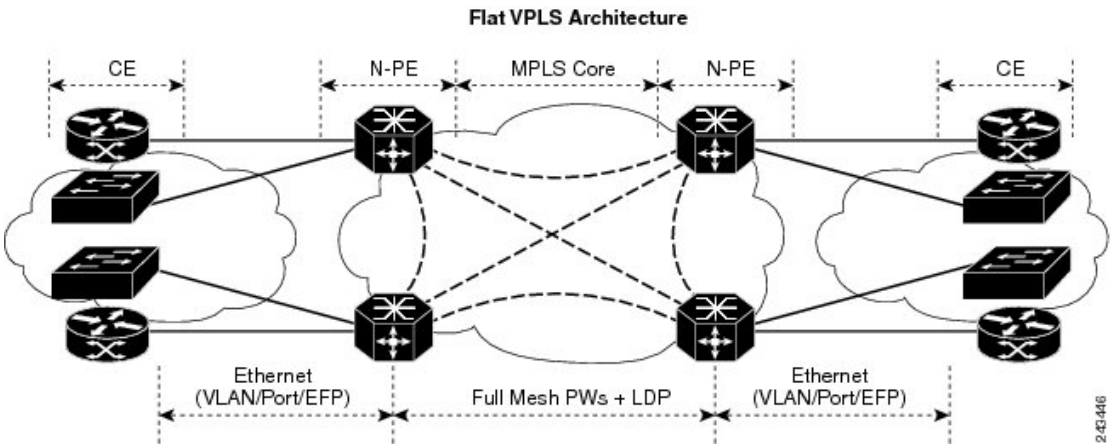
Now, the service provider network starts switching the packets within the bridged domain specific to the customer by looking at destination MAC addresses. All traffic with unknown, broadcast, and multicast destination MAC addresses is flooded to all the connected customer edge devices, which connect to the service provider network. The network-facing provider edge devices learn the source MAC addresses as the packets are flooded. The traffic is unicasted to the customer edge device for all the learned MAC addresses.

In the MPLS provider core, the VPLS pseudowire traffic can be dynamically routed over any interface that supports LDP protocol.

VPLS Architecture

The basic or flat VPLS architecture allows for the end-to-end connection between the provider edge (PE) routers to provide multipoint ethernet services. Following figure shows a flat VPLS architecture illustrating the interconnection between the network provider edge (N-PE) nodes over an IP/MPLS network.

Figure 1: Basic VPLS Architecture



The VPLS network requires the creation of a Bridge Domain (Layer 2 broadcast domain) on each of the PE routers. The VPLS provider edge device holds all the VPLS forwarding MAC tables and bridge domain information. In addition, it is responsible for all flooding broadcast frames and multicast replications.

The PEs in the VPLS architecture are connected with a full mesh of Pseudowires (PWs). A Virtual Forwarding Instance (VFI) is used to interconnect the mesh of pseudowires. A bridge domain is connected to a VFI to create a Virtual Switching Instance (VSI), that provides Ethernet multipoint bridging over a PW mesh. VPLS network links the VSIs using the MPLS pseudowires to create an emulated Ethernet Switch.

With VPLS, all customer equipment (CE) devices participating in a single VPLS instance appear to be on the same LAN and, therefore, can communicate directly with one another in a multipoint topology, without requiring a full mesh of point-to-point circuits at the CE device. A service provider can offer VPLS service to multiple customers over the MPLS network by defining different bridged domains for different customers. Packets from one bridged domain are never carried over or delivered to another bridged domain, thus ensuring the privacy of the LAN service.

VPLS transports Ethernet IEEE 802.3, VLAN IEEE 802.1q, and VLAN-in-VLAN (q-in-q) traffic across multiple sites that belong to the same Layer 2 broadcast domain. VPLS offers simple VLAN services that include flooding broadcast, multicast, and unknown unicast frames that are received on a bridge. The VPLS solution requires a full mesh of pseudowires that are established among PE routers. The VPLS implementation is based on Label Distribution Protocol (LDP)-based pseudowire signaling.

VPLS for Layer 2 Switching

VPLS technology includes the capability of configuring the Cisco ASR 9000 Series Routers to perform Layer 2 bridging. In this mode, the Cisco ASR 9000 Series Routers can be configured to operate like other Cisco switches.

These features are supported:

- Bridging IOS XR Trunk Interfaces
- Bridging on EFPs

Refer to the Configuration Examples for Multipoint Layer 2 Services section for examples on these bridging features.

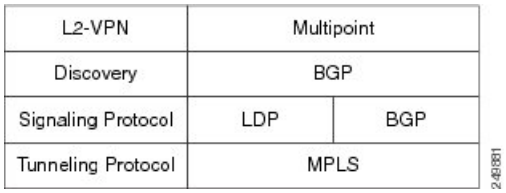
VPLS Discovery and Signaling

VPLS is a Layer 2 multipoint service and it emulates LAN service across a WAN service. VPLS enables service providers to interconnect several LAN segments over a packet-switched network and make it behave as one single LAN. Service provider can provide a native Ethernet access connection to customers using VPLS.

The VPLS control plane consists of two important components, autodiscovery and signaling:

- VPLS Autodiscovery eliminates the need to manually provision VPLS neighbors. VPLS Autodiscovery enables each VPLS PE router to discover the other provider edge (PE) routers that are part of the same VPLS domain.
- Once the PEs are discovered, pseudowires (PWs) are signaled and established across each pair of PE routers forming a full mesh of PWs across PE routers in a VPLS domain

Figure 2: VPLS Autodiscovery and Signaling



BGP-based VPLS Autodiscovery

An important aspect of VPN technologies, including VPLS, is the ability of network devices to automatically signal to other devices about an association with a particular VPN. Autodiscovery requires this information to be distributed to all members of a VPN. VPLS is a multipoint mechanism for which BGP is well suited.

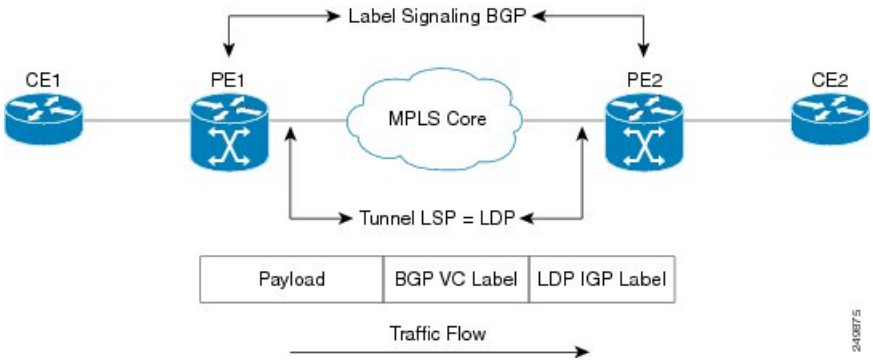
BGP-based VPLS autodiscovery eliminates the need to manually provision VPLS neighbors. VPLS autodiscovery enables each VPLS PE router to discover the other provider edge (PE) routers that are part of the same VPLS domain. VPLS Autodiscovery also tracks when PE routers are added to or removed from the VPLS domain. When the discovery process is complete, each PE router has the information required to setup VPLS pseudowires (PWs).

Even when BGP autodiscovery is enabled, pseudowires can be manually configured for VPLS PE routers that are not participating in the autodiscovery process.

BGP Auto Discovery With BGP Signaling

The implementation of VPLS in a network requires the establishment of a full mesh of PWs between the provider edge (PE) routers. The PWs can be signaled using BGP signaling.

Figure 3: Discovery and Signaling Attributes



The BGP signaling and autodiscovery scheme has the following components:

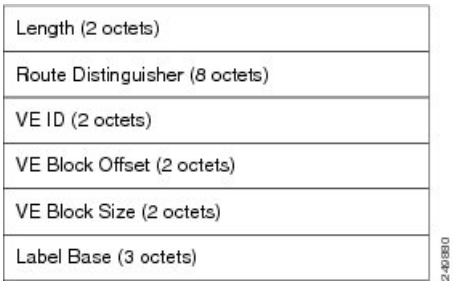
- A means for a PE to learn which remote PEs are members of a given VPLS. This process is known as autodiscovery.
- A means for a PE to learn the pseudowire label expected by a given remote PE for a given VPLS. This process is known as signaling.

The BGP Network Layer Reachability Information (NLRI) takes care of the above two components simultaneously. The NLRI generated by a given PE contains the necessary information required by any other PE. These components enable the automatic setting up of a full mesh of pseudowires for each VPLS without having to manually configure those pseudowires on each PE.

NLRI Format for VPLS with BGP AD and Signaling

The following figure shows the NLRI format for VPLS with BGP AD and Signaling

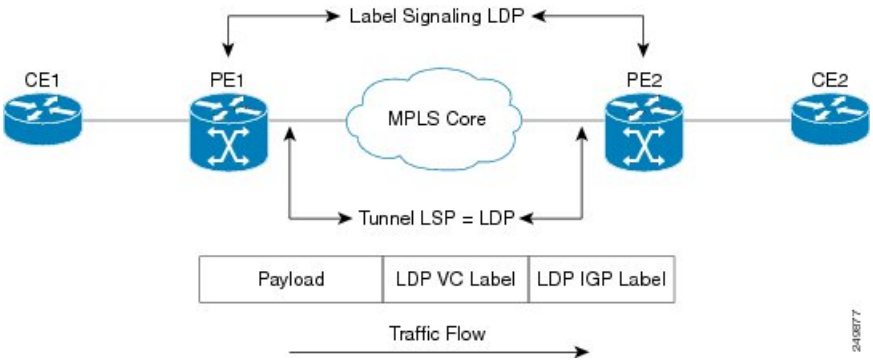
Figure 4: NLRI Format



BGP Auto Discovery With LDP Signaling

Signaling of pseudowires requires exchange of information between two endpoints. Label Distribution Protocol (LDP) is better suited for point-to-point signaling. The signaling of pseudowires between provider edge devices, uses targeted LDP sessions to exchange label values and attributes and to configure the pseudowires.

Figure 5: Discovery and Signaling Attributes



A PE router advertises an identifier through BGP for each VPLS. This identifier is unique within the VPLS instance and acts like a VPLS ID. The identifier enables the PE router receiving the BGP advertisement to identify the VPLS associated with the advertisement and import it to the correct VPLS instance. In this manner, for each VPLS, a PE router learns the other PE routers that are members of the VPLS.

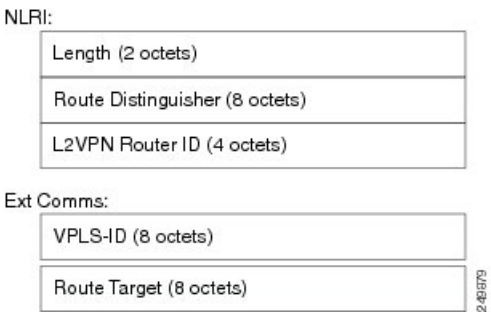
The LDP protocol is used to configure a pseudowire to all the other PE routers. FEC 129 is used for the signaling. The information carried by FEC 129 includes the VPLS ID, the Target Attachment Individual Identifier (TAII) and the Source Attachment Individual Identifier (SAII).

The LDP advertisement also contains the inner label or VPLS label that is expected for the incoming traffic over the pseudowire. This enables the LDP peer to identify the VPLS instance with which the pseudowire is to be associated and the label value that it is expected to use when sending traffic on that pseudowire.

NLRI and Extended Communities

The following figure depicts Network Layer Reachability Information (NLRI) and extended communities (Ext Comms).

Figure 6: NLRI and Extended Communities



Service Path Preference for L2VPN

Service Path Preference feature (SPP) helps control transport path for L2VPN services in traffic engineering (TE) tunnels. SPP feature provides a way for services to influence path selection while forwarding in Multiprotocol Label Switching (MPLS) networks. SPP is achieved by associating a control plane policy with a forward-class. SPP is supported for per-service path selection for VPLS with BGP AD, and EVI for PBB-EVPN and EVPN.

SPP for L2VPN is implemented in two steps:

- Path selection - classify incoming traffic on a per service basis.
- Path setup - set up paths with forward-class service.

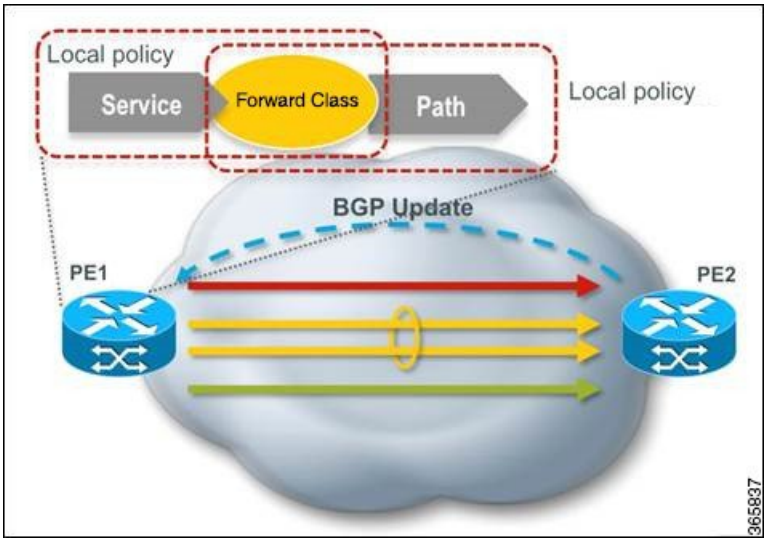
Refer to *Service Path Preference for MPLS VPN Sessions* module for more information on SPP.

Understanding How Service Path Preference Works

SPP allows services to select a path based on policies configured in the control plane.

Consider a scenario where you have two Provider Edge (PE) routers in a setup. PE1 functions as ingress node and PE2 functions as egress node.

Figure 7: Sample Service Path Preference scenario



The ingress PE (PE1) receives the routes from the customers. The local policies determine the attribute to be assigned to the customer. PE1 associates a forward-class to the prefix based on the local policies that are created based on the VFI or EVI service. The pre-configured tunnel with matching forward-class is selected for forwarding the traffic.

L2VPN Route Policy

L2VPN route-policy feature enables the export community configuration for L2VPN VPWS and L2VPN VPLS with BGP autodiscovery. BGP executes the route-policy. This functionality is similar to the route-policy support under BGP submode for L3VPN services.

The following points explain the L2VPN route-policy functionality:

1. The RPL is used to set standard community as policy action for two new attachpoints that are L2VPN export VPLS (VFI) and L2VPN export VPWS (MP2MP).
2. L2VPN configuration specifies which route-policy to use for a given bridge-domain configured with BGP autodiscovery.
3. L2VPN sends the route-policy name to BGP along with the L2VPN context.
4. BGP process inserts standard community to the L2 NLRI.

Interoperability Between Cisco IOS XR and Cisco IOS on VPLS LDP Signaling

The Cisco IOS Software encodes the NLRI length in the fist byte in bits format in the BGP Update message. However, the Cisco IOS XR Software interprets the NLRI length in 2 bytes. Therefore, when the BGP neighbor with VPLS-VPWS address family is configured between the IOS and the IOS XR, NLRI mismatch can happen, leading to flapping between neighbors. To avoid this conflict, IOS supports **prefix-length-size 2** command that needs to be enabled for IOS to work with IOS XR. When the **prefix-length-size 2** command is configured in IOS, the NLRI length is encoded in bytes. This configuration is mandatory for IOS to work with IOS XR.

This is a sample IOS configuration with the **prefix-length-size 2** command:

```
router bgp 1
 address-family l2vpn vpls
  neighbor 5.5.5.2 activate
  neighbor 5.5.5.2 prefix-length-size 2 --------> NLRI length = 2 bytes
 exit-address-family
```

MAC Address-related Parameters

The MAC address table contains a list of the known MAC addresses and their forwarding information. In the current VPLS design, the MAC address table and its management are maintained on the route processor (RP) card.

These topics provide information about the MAC address-related parameters:

Note After you modify the MAC limit or action at the bridge domain level, ensure that you shut and unshut the bridge domain for the action to take effect. If you modify the MAC limit or action on an attachment circuit (through which traffic is passing), the attachment circuit must be shut and unshut for the action to take effect.

MAC Address Flooding

Ethernet services require that frames that are sent to broadcast addresses and to unknown destination addresses be flooded to all ports. To obtain flooding within VPLS broadcast models, all unknown unicast, broadcast, and multicast frames are flooded over the corresponding pseudowires and to all attachment circuits. Therefore, a PE must replicate packets across both attachment circuits and pseudowires.

MAC Address-based Forwarding

To forward a frame, a PE must associate a destination MAC address with a pseudowire or attachment circuit. This type of association is provided through a static configuration on each PE or through dynamic learning, which is flooded to all bridge ports.

Note Split horizon forwarding applies in this case, for example, frames that are coming in on an attachment circuit or pseudowire are sent out of the same pseudowire. The pseudowire frames, which are received on one pseudowire, are not replicated on other pseudowires in the same virtual forwarding instance (VFI).

MAC Address Source-based Learning

When a frame arrives on a bridge port (for example, pseudowire or attachment circuit) and the source MAC address is unknown to the receiving PE router, the source MAC address is associated with the pseudowire or attachment circuit. Outbound frames to the MAC address are forwarded to the appropriate pseudowire or attachment circuit.

MAC address source-based learning uses the MAC address information that is learned in the hardware forwarding path. The updated MAC tables are propagated and programs the hardware for the router.

Note Static MAC move is not supported from one port, interface, or AC to another port, interface, or AC. For example, if a static MAC is configured on AC1 (port 1) and then, if you send a packet with the same MAC as source MAC on AC2 (port 2), then you can't attach this MAC to AC2 as a dynamic MAC. Therefore, do not send any packet with a MAC as any of the static MAC addresses configured.

The number of learned MAC addresses is limited through configurable per-port and per-bridge domain MAC address limits.

MAC Address Aging

A MAC address in the MAC table is considered valid only for the duration of the MAC address aging time. When the time expires, the relevant MAC entries are repopulated. When the MAC aging time is configured only under a bridge domain, all the pseudowires and attachment circuits in the bridge domain use that configured MAC aging time.

A bridge forwards, floods, or drops packets based on the bridge table. The bridge table maintains both static entries and dynamic entries. Static entries are entered by the network manager or by the bridge itself. Dynamic entries are entered by the bridge learning process. A dynamic entry is automatically removed after a specified length of time, known as *aging time*, from the time the entry was created or last updated.

If hosts on a bridged network are likely to move, decrease the aging-time to enable the bridge to adapt to the change quickly. If hosts do not transmit continuously, increase the aging time to record the dynamic entries for a longer time, thus reducing the possibility of flooding when the hosts transmit again.

MAC Address Limit

The MAC address limit is used to limit the number of learned MAC addresses. The bridge domain level limit is always configured and cannot be disabled. The default value of the bridge domain level limit is 4000 and can be changed in the range of 1-512000.

Configure MAC Address Limit

Configure the MAC address limit using the **maximum** command. The MAC address learning is restricted to the configured limit.

When the number of learned MAC addresses reaches the configured limit, you can configure the bridge behavior by using the **action** command. You can configure the action to perform one of the following:

- **flood**: All the unknown unicast packets, with unknown destinations addresses, are flooded over the bridge.
- **no-flood**: All the unknown unicast packets, with unknown destination addresses, are dropped.
- **shutdown** : All the packets are dropped.

When the MAC limit is exceeded, use the **notification {both | none | trap}** command to send notifications in one of the following forms:

- **trap**: Sends Simple Network Management Protocol (SNMP) trap notification.
- **both**: Sends both syslog and trap notifications.
- **none**: No notifications are sent.

By default, syslog message is sent.

Configuration Example

In this example, MAC address limit is configured as 5000 and MAC limit action is set to flood the packets. As notification is not configured, syslog entries are sent when the MAC limit is exceeded.

```
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# bridge group bg-0
Router(config-l2vpn-bg)# bridge-domain bd-0
Router(config-l2vpn-bg-bd)# mac
Router(config-l2vpn-bg-bd-mac)# limit
Router(config-l2vpn-bg-bd-mac-limit)# maximum 5000
Router(config-l2vpn-bg-bd-mac-limit)# action flood
```

Verification

Use the **show l2vpn bridge-domain** command to view the MAC address limit configuration.

```
Router# show l2vpn bridge-domain bd-name bd-0 detail
Legend: pp = Partially Programmed.
Bridge group: bg-0, bridge-domain: bd-0, id: 25, state: up, ShgId: 0, MSTi: 0
  Coupled state: disabled
  VINE state: EVPN Native
  MAC learning: enabled
  MAC withdraw: enabled
    MAC withdraw for Access PW: enabled
    MAC withdraw sent on: bridge port up
    MAC withdraw relaying (access to access): disabled
  Flooding:
    Broadcast & Multicast: enabled
    Unknown unicast: enabled
  MAC aging time: 300 s, Type: inactivity
  MAC limit: 5000, Action: flood, Notification: syslog
  MAC limit reached: no, threshold: 80%
  MAC port down flush: enabled
  MAC Secure: disabled, Logging: disabled
```

MAC Address Withdrawal

For faster VPLS convergence, you can remove or unlearn the MAC addresses that are learned dynamically. The Label Distribution Protocol (LDP) Address Withdrawal message is sent with the list of MAC addresses, which need to be withdrawn to all other PEs that are participating in the corresponding VPLS service.

For the Cisco IOS XR VPLS implementation, a portion of the dynamically learned MAC addresses are cleared by using the MAC addresses aging mechanism by default. The MAC address withdrawal feature is added through the LDP Address Withdrawal message. To enable the MAC address withdrawal feature, use the **withdrawal** command in l2vpn bridge group bridge domain MAC configuration mode. To verify that the MAC address withdrawal is enabled, use the **show l2vpn bridge-domain** command with the **detail** keyword.

Note By default, the LDP MAC Withdrawal feature is enabled on Cisco IOS XR.

The LDP MAC Withdrawal feature is generated due to these events:

- Attachment circuit goes down. You can remove or add the attachment circuit through the CLI.

- MAC withdrawal messages are received over a VFI pseudowire. RFC 4762 specifies that both wildcards (by means of an empty Type, Length and Value [TLV]) and a specific MAC address withdrawal. Cisco IOS XR software supports only a wildcard MAC address withdrawal.

MAC Address Security

You can configure MAC address security at the interfaces and at the bridge access ports (subinterfaces) levels. However, MAC security configured under an interface takes precedence to MAC security configured at the bridge domain level. When a MAC address is first learned, on an EFP that is configured with MAC security and then, the same MAC address is learned on another EFP, these events occur:

- the packet is dropped
- the second EFP is shutdown
- the packet is learned and the MAC from the original EFP is flushed

MAC Loop Prevention

Table 1: Feature History Table

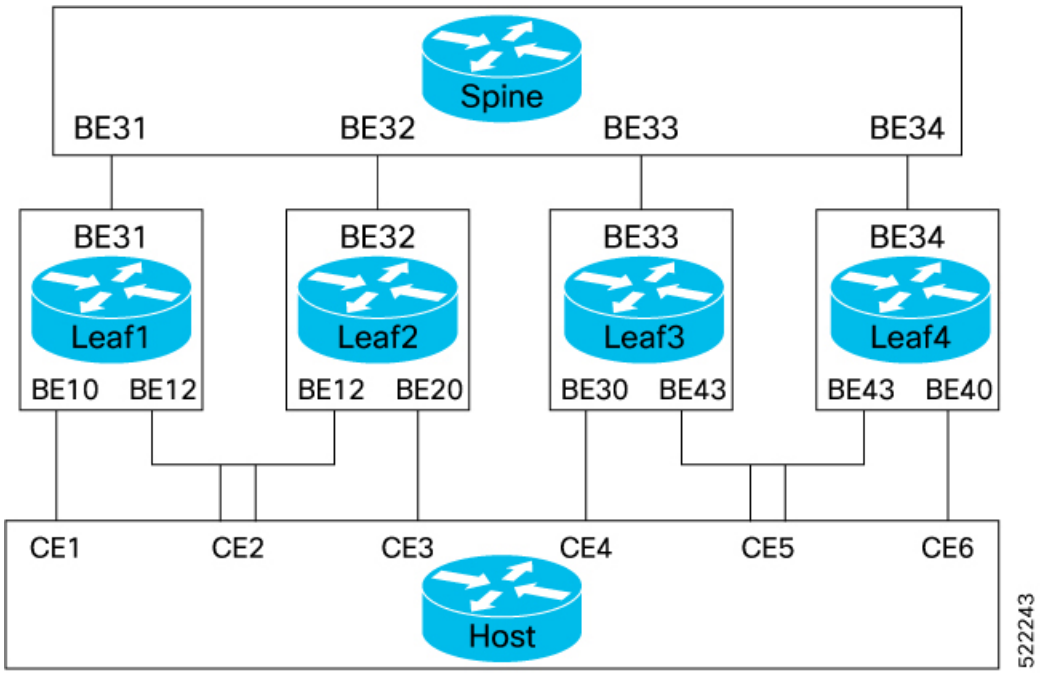
Feature Name	Release Information	Feature Description
MAC Loop Prevention	Release 7.5.2	This feature helps reduce network congestion and avoid traffic loss by shutting down a port after it reaches the configured number of MAC moves within the specified move interval. You can configure this feature at the bridge-domain level using the **mac secure** command. This feature is now supported on routers that have Cisco NC57 line cards installed and operate in native and compatibility modes.

In case of network instability like an interface flap, a MAC address might be learned from a new interface. This is normal network convergence, and the mac-address-table is updated dynamically. A MAC move occurs when the same MAC address is learned on multiple interfaces. However, constant MAC moves often indicate network instability during an L2 loop. This feature lets you report MAC moves and take corrective actions such as shutting down an offending port.

The MAC Loop Prevention feature allows you to shut down the port after it exceeds the configured number of MAC moves within the specified move interval. You can configure this feature at the bridge-domain level using the **mac secure** command. The default number of MAC moves is five times for a move interval of 180 seconds. If the number of MAC moves exceeds the configured value, the MAC entry is marked as duplicate and the port is shut down. This feature helps you to reduce network congestion and avoid traffic loss. This feature is supported on physical and bundle AC, PW, and EVPN.

You can recover the shutdown port after a particular time by using the **shutdown-recovery-timeout** command after which the port automatically becomes active. If the recovery time is not configured, the shutdown port is recovered after three times of move interval. For example, if the move interval is 30 seconds, the shutdown port becomes active after 90 seconds.

Let’s see how this feature works in the following scenarios:



- MAC learning within the node - When Leaf1 learns the same MAC address on both the interfaces, BE10 and BE12, the MAC is marked as duplicate and the port is shutdown after it exceeds the configured number of MAC moves within specified interval. For example, consider the MAC move count is configured as 5 for 180 seconds. If the traffic flows starts from BE10, and, the configured MAC move count ends at interface BE12, the port at the interface BE12 is shutdown.
- MAC learning between the nodes - When the same MAC address is learnt on BE10 and 20, the MAC is marked as duplicate and the port is shutdown after it exceeds the configured number of MAC moves within specified interval. For example, consider the MAC move count is configured as 5 for 180 seconds. If the traffic starts from BE10, the configured MAC move count ends at interface BE20, the port at the interface BE20 is shutdown.

Note When a Leaf that is enabled with this feature receives two MACs from the Leafs that are not enabled with this feature, this feature won't take effect.

Configuration Example

Perfrom this task on a Leaf to configure MAC loop prevention.

```
/* MAC Loop Prevention for VPLS */
Router#configure
Router(config)#l2vpn
Router(config-l2vpn)#bridge-group BG1
Router(config-l2vpn-bg)#bridge-domain BD1
Router(config-l2vpn-bg-bd)#mac secure
Router(config-l2vpn-bg-bd-mac-sec)#action shutdown
Router(config-l2vpn-bg-bd-mac-sec)#threshold
Router(config-l2vpn-bg-bd-mac-sec)#shutdown-recovery-timeout 300
Router(config-l2vpn-bg-bd-mac-sec)#exit
```

```
Router(config-l2vpn-bg-bd)#interface GigabitEthernet0/2/0/0.1
Router(config-l2vpn-bg-bd-ac)#exit
Router(config-l2vpn-bg-bd)#interface GigabitEthernet0/2/0/0.2
Router(config-l2vpn-bg-bd-ac)#commit

/* MAC Loop Prevention for PW */
Router#configure
Router(config)#l2vpn
Router(config-l2vpn)#bridge-group BG1
Router(config-l2vpn-bg)#bridge-domain BD1
Router(config-l2vpn-bg-bd)#mac secure
Router(config-l2vpn-bg-bd-mac-sec)#action shutdown
Router(config-l2vpn-bg-bd-mac-sec)#threshold
Router(config-l2vpn-bg-bd-mac-sec)#shutdown-recovery-timeout 300
Router(config-l2vpn-bg-bd-mac-sec)#exit
Router(config-l2vpn-bg-bd)#interface GigabitEthernet0/2/0/0.3
Router(config-l2vpn-bg-bd-ac)#exit
Router(config-l2vpn-bg-bd)#vfi VFI1
Router(config-l2vpn-bg-bd-vfi)#neighbor 192.168.0.4 pw-id 3
Router(config-l2vpn-bg-bd-vfi-pw)#commit

/* MAC Loop Prevention for EVPN */
Router#configure
Router(config)#l2vpn
Router(config-l2vpn)#bridge-group BG1
Router(config-l2vpn-bg)#bridge-domain BD1
Router(config-l2vpn-bg-bd)#mac secure
Router(config-l2vpn-bg-bd-mac-sec)#action shutdown
Router(config-l2vpn-bg-bd-mac-sec)#threshold
Router(config-l2vpn-bg-bd-mac-sec)#shutdown-recovery-timeout 300
Router(config-l2vpn-bg-bd-mac-sec)#exit
Router(config-l2vpn-bg-bd)#interface GigabitEthernet0/2/0/0.3
Router(config-l2vpn-bg-bd-ac)#exit
Router(config-l2vpn-bg-bd)#evi 100
Router(config-l2vpn-bg-bd-evi)#commit

/* Configure move count and move-interval */
Router#configure
Router(config)#evpn
Router(config-evpn)#mac secure
Router(config-evpn-mac-secure)#move-count 7
Router(config-evpn-mac-secure)#move-interval 30
Router(config-evpn-mac-secure)#commit
```

Running Configuration

This section shows the MAC loop prevention running configuration.

```
/* MAC Loop Prevention for VPLS */
l2vpn
 bridge group BG1
  bridge-domain BD1
   mac
    secure
     action shutdown
     threshold
     shutdown-recovery-timeout 300
    !
   interface GigabitEthernet0/2/0/0.1
   interface GigabitEthernet0/2/0/0.2
  !
```

```
/* MAC Loop Prevention for PW */
l2vpn
 bridge group BG1
  bridge-domain BD1
   mac
    secure
     action shutdown
     threshold
     shutdown-recovery-timeout 300
    !
   interface GigabitEthernet0/2/0/0.3
  !
   vfi VFI1
    neighbor 192.168.0.4 pw-id 3

/* MAC Loop Prevention for EVPN */
l2vpn
 bridge group BG1
  bridge-domain BD1
   mac
    secure
     action shutdown
     threshold
     shutdown-recovery-timeout 300
    !
   interface GigabitEthernet0/2/0/0.3
  !
   evi 100
!
/* Configure move-count and move-interval */
evpn
 mac
  secure
   move-count 7
   move-interval 30
 !
```

Verification

Verify that you have successfully configured the MAC Loop Prevention feature. The following show output displays the MAC security information:

```
Router# show l2vpn bridge-doamin detail
Bridge group: bg1, bridge-domain: bd1, id: 0, state: up, ShgId: 0, MSTi: 0
  MAC Secure: enabled, Logging: disabled, Action: shutdown, Threshold: enabled
MAC Secure Shutdown recovery timer : 300
List of ACs:
    AC: interface GigabitEthernet0/2/0/0.1, state is up
    AC: interface GigabitEthernet0/2/0/0.2, state is up
      MAC Secure: enabled, Logging: disabled, Action: shutdown, Threshold: enabled
      MAC Secure Shutdown recovery timer: 300
```

MAC Security Recovery

MAC security recovery feature enables you to recover the bridge port or Ethernet flow point (EFP) that is shut down due to MAC security violation. The recovery is achieved by configuring a shutdown recovery timer, using the **mac secure shutdown-recovery-timeout** command. The bridge port or EFP that is shut down, is UP automatically after the timer expires. The MAC security recovery feature takes effect only when you have enabled *shutdown* to be the default action for violating MAC security policies.

Restrictions for MAC Security Recovery

- The MAC security recovery applies only for the EFP security.
- The shutdown recovery timer does not apply to MAC limits configured on a per-EFP level, per-bridge domain level, or both.

For more information on configuring MAC security recovery, see Configure MAC Security Recovery, on page 20section.

Configure MAC Security Recovery

Perform this task to configure MAC security recovery under the following:

- bridge domain
- bridge port or attachment circuit (AC)
- access pseudowire (PW)

```
/* Configure MAC security recovery under bridge domain */

Router(config)# l2vpn
Router(config-l2vpn)# bridge group bg1
Router(config-l2vpn-bg)# bridge-domain bd-1-6
Router(config-l2vpn-bg-bd)# mac
Router(config-l2vpn-bg-bd-mac)# aging
Router(config-l2vpn-bg-bd-mac-aging)# time 900
Router(config-l2vpn-bg-bd-mac-aging)# secure
Router(config-l2vpn-bg-bd-mac-secure)# action shutdown
Router(config-l2vpn-bg-bd-mac-secure)# logging
Router(config-l2vpn-bg-bd-mac-secure)# shutdown-recovery-timeout 100
Router(config-l2vpn-bg-bd-mac-secure)#    !
```

```
/* Configure MAC security recovery under bridge port or attachment circuit (AC) */

Router(config-l2vpn-bg-bd-mac-secure)# interface GigabitEthernet 0/0/0/5.11
Router(config-l2vpn-bg-bd-ac)# mac
Router(config-l2vpn-bg-bd-ac-mac)# secure
Router(config-l2vpn-bg-bd-ac-mac-secure)# action shutdown
Router(config-l2vpn-bg-bd-ac-mac-secure)# logging
Router(config-l2vpn-bg-bd-ac-mac-secure)# shutdown-recovery-timeout 600
Router(config-l2vpn-bg-bd-ac-mac-secure)# !
```

```
/* Configure MAC security recovery over access pseudowire (PW) */

Router(config-l2vpn-bg-bd-ac-mac-secure)# neighbor 64.64.64.3 pw-id 2300001
Router(config-l2vpn-bg-bd-pw)# !
Router(config-l2vpn-bg-bd-pw)# neighbor 64.64.64.4 pw-id 2400001
Router(config-l2vpn-bg-bd-pw)# mac
Router(config-l2vpn-bg-bd-pw-mac)# secure
Router(config-l2vpn-bg-bd-pw-mac-secure)# action shutdown
Router(config-l2vpn-bg-bd-pw-mac-secure)# logging
Router(config-l2vpn-bg-bd-pw-mac-secure)# shutdown-recovery-timeout 600
Router(config-l2vpn-bg-bd-pw-mac-secure)# !
```

Running Configuration for MAC Security Recovery

This example shows how to configure MAC security recovery for L2VPN under bridge domain.

```
config
l2vpn
 bridge group bg1
```

```
 bridge-domain bd-1-6
  mac
    aging
      time 900
!
  secure
   action shutdown
     logging
       shutdown-recovery-timeout 30
       !
     !
```

This example shows how to configure MAC security recovery for L2VPN under attachment circuit (AC).

```
Interface GigabitEthernet 0/0/0/5.11
mac
  secure
   action shutdown
     logging
       shutdown-recovery-timeout 600
```

This example shows how to configure MAC security recovery for L2VPN over access pseudowires.

```
neighbor 64.64.64.3 pw-id 2300001
!
neighbor 64.64.64.4 pw-id 2400001
 mac
  secure
   action shutdown
     logging
       shutdown-recovery-timeout 600
```

Verify MAC Security Recovery

This sample output verifies that the MAC security recovery is enabled under bridge domain, and also displays the value that is set for Shutdown recovery timer.

```
RP/0/RSP0/CPU0:router# show l2vpn bridge-domain bd-name bd-1-6 detail
Legend: pp = Partially Programmed.
Bridge group: bg1, bridge-domain: bd-1-6, id: 5, state: up, ShgId: 0, MSTi: 0
  Coupled state: disabled
  VINE state: Default
  MAC learning: enabled
  MAC withdraw: enabled
    MAC withdraw for Access PW: enabled
    MAC withdraw sent on: bridge port up
    MAC withdraw relaying (access to access): disabled
  Flooding:
    Broadcast & Multicast: enabled
    Unknown unicast: enabled
  MAC aging time: 900 s, Type: inactivity
  MAC limit: 4000, Action: none, Notification: syslog
  MAC limit reached: no, threshold: 75%
  MAC port down flush: enabled
  MAC Secure: enabled, Logging: enabled, Action: shutdown, Threshold: disabled
  MAC Secure Shutdown recovery timer : 30 sec
  Split Horizon Group: none
```

This sample output verifies that the MAC security recovery is enabled under an attachment circuit (AC), and also displays the value that is set for Shutdown recovery timer.

```
RP/0/RSP0/CPU0:router# show l2vpn bridge-domain bd-name bd-1-6 detail

ACs: 1 (1 up), VFIs: 0, PWs: 2 (2 up), PBBs: 0 (0 up), VNIs: 0 (0 up)
  List of ACs:
```

```
    AC: GigabitEthernet0/0/0/5.11, state is up
      Type VLAN; Num Ranges: 1
      Outer Tag: 21
      Rewrite Tags: []
      VLAN ranges: [11, 11]
      MTU 1500; XC ID 0x1205e26; interworking none
      MAC learning: enabled
      Flooding:
        Broadcast & Multicast: e nabled
        Unknown unicast: enabled
      MAC aging time: 900 s, Type: inactivity
      MAC limit: 4000, Action: none, Notification: syslog
      MAC limit reached: no, threshold: 75%
      MAC port down flush: enabled
      MAC Secure: enabled, Logging: enabled, Action: shutdown, Threshold: disabled
      MAC Secure Shutdown recovery timer : 600 sec
      Split Horizon Group: none
      E-Tree: Root
```

This sample output verifies that the MAC security recovery is enabled under access pseudowires, and also displays the value that is set for Shutdown recovery timer.

```
RP/0/RSP0/CPU0:router# show l2vpn bridge-domain bd-name bd-1-6 detail

List of Access PWs:
    PW: neighbor 64.64.64.3, PW ID 2300001, state is up ( established )
      PW class not set, XC ID 0xa0000019
      Encapsulation MPLS, protocol LDP
      Source address 64.64.64.2
      PW type Ethernet, control word disabled, interworking none
      PW backup disable delay 0 sec
      Sequencing not set
      LSP : Up
      PW Status TLV in use
        MPLS         Local                          Remote
        ------------ ------------------------------ --------------------------
        Label        60029                          24013
        Group ID     0x5                            0x5
        Interface    Access PW                      Access PW
        MTU          1500                           1500
        Control word disabled                       disabled
        PW type      Ethernet                       Ethernet
        VCCV CV type 0x2                            0x2
                     (LSP ping verification)        (LSP ping verification)
        VCCV CC type 0x6                            0x6
                     (router alert label)           (router alert label)
                     (TTL expiry)                   (TTL expiry)
        ------------ ------------------------------ --------------------------
      Incoming Status (PW Status TLV):
        Status code: 0x0 (Up) in Notification message
      MIB cpwVcIndex: 2684354585
      Create time: 14/08/2018 11:51:56 (04:28:11 ago)
      Last time status changed: 14/08/2018 11:51:57 (04:28:10 ago)
      MAC aging time: 900 s, Type: inactivity
      MAC limit: 4000, Action: none, Notification: syslog
      MAC limit reached: no, threshold: 75%
      MAC port down flush: enabled
     MAC Secure: enabled, Logging: enabled, Action: shutdown, Threshold: disabled
     MAC Secure Shutdown recovery timer: 30 sec
```

You can also use the **Show l2vpn forwarding interface interface-name hardware ingress detail location location-id** command to verify the values that are configured for the Shutdown recovery timer.

Syslog Messages

When MAC secure logging is configured and security violation occurs, syslog messages are displayed.

A sample syslog message is shown as follows. It indicates that the MAC is initially learnt on pseudowires (PW). When the same MAC is learnt on AC GigabitEthernet0_0_0_5.11, MAC secure configured under AC detects security violation. Then, the action configured under PW, which is shutdown in this case, is imposed on AC. Therefore, AC is brought down. If recovery timer is configured under AC, the AC is down until recovery timer expires. After the timer expires, AC is brought up.

```
%L2-L2FIB-5-SECURITY_MAC_SECURE_VIOLATION_AC : MAC secure in AC GigabitEthernet0_0_0_5.11
 detected violated packet that was previously learned in PW neighbor: 64.64.64.3,
ID: 2300001- source MAC: 0065.0600.0001, destination MAC: 0067.0600.0001; action: shutdown
```

MAC Address Move and Unicast Traffic Counters

MAC Address Move and Unicast Traffic counters are introduced on the VPLS bridge ports on the ASR9K platform. These counters essentially are L2VPN bridge port stats counters. MAC move and unicast traffic counters are introduced for troubleshooting. Cisco ASR 9000 High Density 100GE Ethernet Line Cards and Cisco ASR 9000 Enhanced Ethernet Line Cards support these counters.

For more information, on MAC Move and Unicast Traffic counters, use the **show l2vpn bridge-domain** command with the **detail** keyword on an AC Bridge, PW Bridge, PBB Edge, and VXLAN Bridge Ports.

Note If the bridge port traffic is forwarded, either completely or partially to ASR 9000 Ethernet line cards, MAC Address Move and Unicast Traffic counters may not be accurate.

LSP Ping over VPWS and VPLS

For Cisco IOS XR software, the existing support for the Label Switched Path (LSP) ping and traceroute verification mechanisms for point-to-point pseudowires (signaled using LDP FEC128) is extended to cover the pseudowires that are associated with the VFI (VPLS). Currently, the support for the LSP ping and traceroute for LDP signalled FEC128 pseudowires is limited to manually configured VPLS pseudowires. In addition, Cisco IOS XR software supports LSP ping for point-to-point single-segment pseudowires that are signalled using LDP FEC129 AII-type 2 applicable to VPWS or signalled using LDP FEC129 AII-type 1 applicable to VPLS. For information about Virtual Circuit Connection Verification (VCCV) support and the **ping mpls pseudowire** command, see the *MPLS Command Reference for Cisco ASR 9000 Series Routers*.

Split Horizon Groups

An IOS XR bridge domain aggregates attachment circuits (ACs) and pseudowires (PWs) in one of three groups called Split Horizon Groups. When applied to bridge domains, Split Horizon refers to the flooding and forwarding behavior between members of a Split Horizon group. The following table describes how frames received on one member of a split horizon group are treated and if the traffic is forwarded out to the other members of the same split horizon group.

Bridge Domain traffic is either unicast or multicast.

Flooding traffic consists of unknown unicast destination MAC address frames; frames sent to Ethernet multicast addresses (Spanning Tree BPDUs, etc.); Ethernet broadcast frames (MAC address FF-FF-FF-FF-FF-FF).

Known Unicast traffic consists of frames sent to bridge ports that were learned from that port using MAC learning.

Traffic flooding is performed for broadcast, multicast and unknown unicast destination address.

Table 2: Split Horizon Groups Supported in Cisco IOS-XR

Split Horizon Group	Who belongs to this Group?	Multicast within Group	Unicast within Group
0	Default—any member not covered by groups 1 or 2.	Yes	Yes
1	Any PW configured under VFI.	No	No
2	Any AC or PW configured with split-horizon keyword.	No	No

Important notes on Split Horizon Groups:

- All bridge ports or PWs that are members of a bridge domain must belong to one of the three groups.
- By default, all bridge ports or PWs are members of group 0.
- The VFI configuration submode under a bridge domain configuration indicates that members under this domain are included in group 1.
- A PW that is configured in group 0 is called an Access Pseudowire.
- The **split-horizon group** command is used to designate bridge ports or PWs as members of group 2.
- The ASR9000 only supports one VFI group.

Layer 2 Security

These topics describe the Layer 2 VPN extensions to support Layer 2 security:

Port Security

Use port security with dynamically learned and static MAC addresses to restrict a port's ingress traffic by limiting the MAC addresses that are allowed to send traffic into the port. When secure MAC addresses are assigned to a secure port, the port does not forward ingress traffic that has source addresses outside the group of defined addresses. If the number of secure MAC addresses is limited to one and assigned a single secure MAC address, the device attached to that port has the full bandwidth of the port.

These port security features are supported:

- Limits the MAC table size on a bridge or a port.
- Facilitates actions and notifications for a MAC address.
- Enables the MAC aging time and mode for a bridge or a port.
- Filters static MAC addresses on a bridge or a port.
- Marks ports as either secure or nonsecure.
- Enables or disables flooding on a bridge or a port.

After you have set the maximum number of secure MAC addresses on a port, you can configure port security to include the secure addresses in the address table in one of these ways:

- Statically configure all secure MAC addresses by using the **static-address** command.
- Allow the port to dynamically configure secure MAC addresses with the MAC addresses of connected devices.
- Statically configure a number of addresses and allow the rest to be dynamically configured.

Dynamic Host Configuration Protocol Snooping

Dynamic Host Configuration Protocol (DHCP) snooping is a security feature that acts like a firewall between untrusted hosts and trusted DHCP servers. The DHCP snooping feature performs these activities:

- Validates DHCP messages received from untrusted sources and filters out invalid messages.
- Rate-limits DHCP traffic from trusted and untrusted sources.
- Builds and maintains the binding database of DHCP snooping, which contains information about untrusted hosts with leased IP addresses.
- Utilizes the binding database of DHCP snooping to validate subsequent requests from untrusted hosts.

For additional information regarding DHCP, see the *Cisco ASR 9000 Series Aggregation Services Router IP Addresses and Services Configuration Guide*.

G.8032 Ethernet Ring Protection

Ethernet Ring Protection (ERP) protocol, defined in ITU-T G.8032, provides protection for Ethernet traffic in a ring topology, while ensuring that there are no loops within the ring at the Ethernet layer. The loops are prevented by blocking either a pre-determined link or a failed link.

Overview

Each Ethernet ring node is connected to adjacent Ethernet ring nodes participating in the Ethernet ring using two independent links. A ring link never allows formation of loops that affect the network. The Ethernet ring uses a specific link to protect the entire Ethernet ring. This specific link is called the ring protection link (RPL). A ring link is bound by two adjacent Ethernet ring nodes and a port for a ring link (also known as a ring port).

Note The minimum number of Ethernet ring nodes in an Ethernet ring is two.

The fundamentals of ring protection switching are:

- the principle of loop avoidance
- the utilization of learning, forwarding, and Filtering Database (FDB) mechanisms

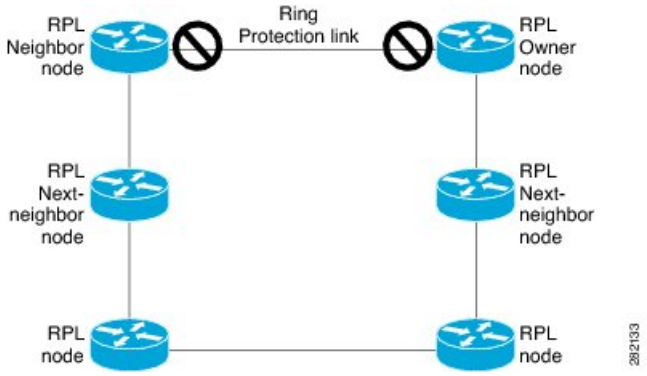
Loop avoidance in an Ethernet ring is achieved by ensuring that, at any time, traffic flows on all but one of the ring links which is the RPL. Multiple nodes are used to form a ring:

- RPL owner—It is responsible for blocking traffic over the RPL so that no loops are formed in the Ethernet traffic. There can be only one RPL owner in a ring.

- RPL neighbor node—The RPL neighbor node is an Ethernet ring node adjacent to the RPL. It is responsible for blocking its end of the RPL under normal conditions. This node type is optional and prevents RPL usage when protected.
- RPL next-neighbor node—The RPL next-neighbor node is an Ethernet ring node adjacent to RPL owner node or RPL neighbor node. It is mainly used for FDB flush optimization on the ring. This node is also optional.

The following figure illustrates the G.8032 Ethernet ring.

Figure 8: G.8032 Ethernet Ring



Nodes on the ring use control messages called RAPS to coordinate the activities of switching on or off the RPL link. Any failure along the ring triggers a RAPS signal fail (RAPS SF) message along both directions, from the nodes adjacent to the failed link, after the nodes have blocked the port facing the failed link. On obtaining this message, the RPL owner unblocks the RPL port.

Note A single link failure in the ring ensures a loop-free topology.

Line status and Connectivity Fault Management protocols are used to detect ring link and node failure. During the recovery phase, when the failed link is restored, the nodes adjacent to the restored link send RAPS no request (RAPS NR) messages. On obtaining this message, the RPL owner blocks the RPL port and sends RAPS no request, root blocked (RAPS NR, RB) messages. This causes all other nodes, other than the RPL owner in the ring, to unblock all blocked ports. The ERP protocol is robust enough to work for both unidirectional failure and multiple link failure scenarios in a ring topology.

A G.8032 ring supports these basic operator administrative commands:

- Force switch (FS)—Allows operator to forcefully block a particular ring-port.
  - Effective even if there is an existing SF condition
  - Multiple FS commands for ring supported
  - May be used to allow immediate maintenance operations
- Manual switch (MS)—Allows operator to manually block a particular ring-port.
  - Ineffective in an existing FS or SF condition
  - Overridden by new FS or SF conditions

    - Multiple MS commands cancel all MS commands

- Clear—Cancels an existing FS or MS command on the ring-port
    - Used (at RPL Owner) to clear non-revertive mode

A G.8032 ring can support multiple instances. An instance is a logical ring running over a physical ring. Such instances are used for various reasons, such as load balancing VLANs over a ring. For example, odd VLANs may go in one direction of the ring, and even VLANs may go in the other direction. Specific VLANs can be configured under only one instance. They cannot overlap multiple instances. Otherwise, data traffic or RAPS packet can cross logical rings, and that is not desirable.

G.8032 ERP provides a new technology that relies on line status and Connectivity Fault Management (CFM) to detect link failure. By running CFM Continuity Check Messages (CCM) messages at an interval of 100ms, it is possible to achieve SONET-like switching time performance and loop free traffic.

For more information about Ethernet Connectivity Fault Management (CFM) and Ethernet Fault Detection (EFD) configuration, refer to the *Configuring Ethernet OAM on the Cisco ASR 9000 Series Router* module in the *Cisco ASR 9000 Series Aggregation Services Router Interface and Hardware Component Configuration Guide*.

Timers

G.8032 ERP specifies the use of different timers to avoid race conditions and unnecessary switching operations:

- Delay Timers—used by the RPL Owner to verify that the network has stabilized before blocking the RPL
    - After SF condition, Wait-to-Restore (WTR) timer is used to verify that SF is not intermittent. The WTR timer can be configured by the operator, and the default time interval is 5 minutes. The time interval ranges from 1 to 12 minutes.
    - After FS/MS command, Wait-to-Block timer is used to verify that no background condition exists.

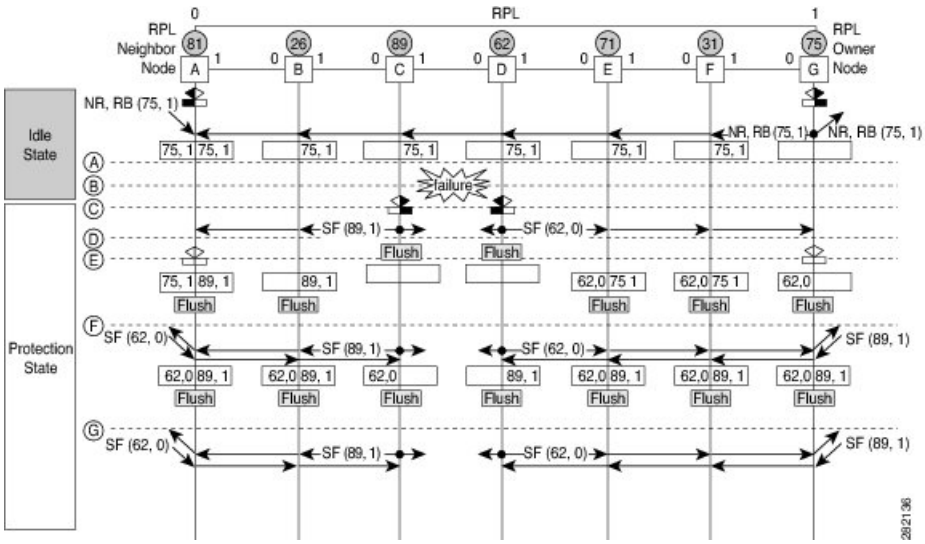
Note Wait-to-Block timer may be shorter than the Wait-to-Restore timer

- Guard Timer—used by all nodes when changing state; it blocks latent outdated messages from causing unnecessary state changes. The Guard timer can be configured and the default time interval is 500 ms. The time interval ranges from 10 to 2000 ms.
- Hold-off timers—used by underlying Ethernet layer to filter out intermittent link faults. The hold-off timer can be configured and the default time interval is 0 seconds. The time interval ranges from 0 to 10 seconds.
    - Faults are reported to the ring protection mechanism, only if this timer expires.

Single Link Failure

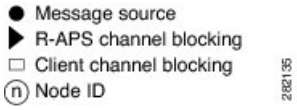
The following figure represents protection switching in case of a single link failure.

Figure 9: G.8032 Single Link Failure



The following figure represents an Ethernet ring composed of seven Ethernet ring nodes. The RPL is the ring link between Ethernet ring nodes A and G. In these scenarios, both ends of the RPL are blocked. Ethernet ring node G is the RPL owner node, and Ethernet ring node A is the RPL neighbor node.

These symbols are used:

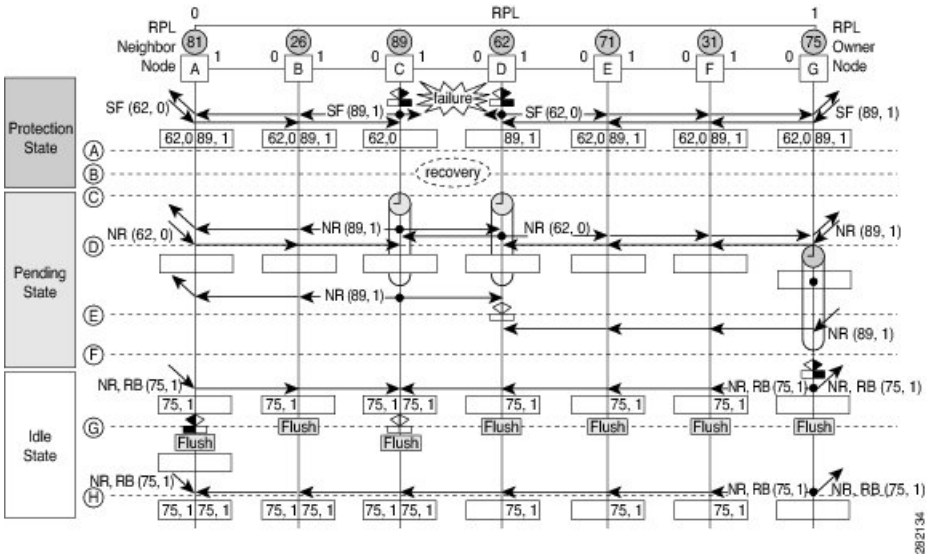


This sequence describes the steps in the single link failure, represented in Figure 8:

1. Link operates in the normal condition.
2. A failure occurs.
3. Ethernet ring nodes C and D detect a local Signal Failure condition and after the holdoff time interval, block the failed ring port and perform the FDB flush.
4. Ethernet ring nodes C and D start sending RAPS (SF) messages periodically along with the (Node ID, BPR) pair on both ring ports, while the SF condition persists.
5. All Ethernet ring nodes receiving an RAPS (SF) message perform FDB flush. When the RPL owner node G and RPL neighbor node A receive an RAPS (SF) message, the Ethernet ring node unblocks it's end of the RPL and performs the FDB flush.
6. All Ethernet ring nodes receiving a second RAPS (SF) message perform the FDB flush again; this is because of the Node ID and BPR-based mechanism.
7. Stable SF condition—RAPS (SF) messages on the Ethernet Ring. Further RAPS (SF) messages trigger no further action.

The following figure represents reversion in case of a single link failure.

Figure 10: Single link failure Recovery (Revertive operation)



This sequence describes the steps in the single link failure recovery, as represented in Figure 9:

1. Link operates in the stable SF condition.
2. Recovery of link failure occurs.
3. Ethernet ring nodes C and D detect clearing of signal failure (SF) condition, start the guard timer and initiate periodical transmission of RAPS (NR) messages on both ring ports. (The guard timer prevents the reception of RAPS messages).
4. When the Ethernet ring nodes receive an RAPS (NR) message, the Node ID and BPR pair of a receiving ring port is deleted and the RPL owner node starts the WTR timer.
5. When the guard timer expires on Ethernet ring nodes C and D, they may accept the new RAPS messages that they receive. Ethernet ring node D receives an RAPS (NR) message with higher Node ID from Ethernet ring node C, and unblocks its non-failed ring port.
6. When WTR timer expires, the RPL owner node blocks its end of the RPL, sends RAPS (NR, RB) message with the (Node ID, BPR) pair, and performs the FDB flush.
7. When Ethernet ring node C receives an RAPS (NR, RB) message, it removes the block on its blocked ring ports, and stops sending RAPS (NR) messages. On the other hand, when the RPL neighbor node A receives an RAPS (NR, RB) message, it blocks its end of the RPL. In addition to this, Ethernet ring nodes A to F perform the FDB flush when receiving an RAPS (NR, RB) message, due to the existence of the Node ID and BPR based mechanism.

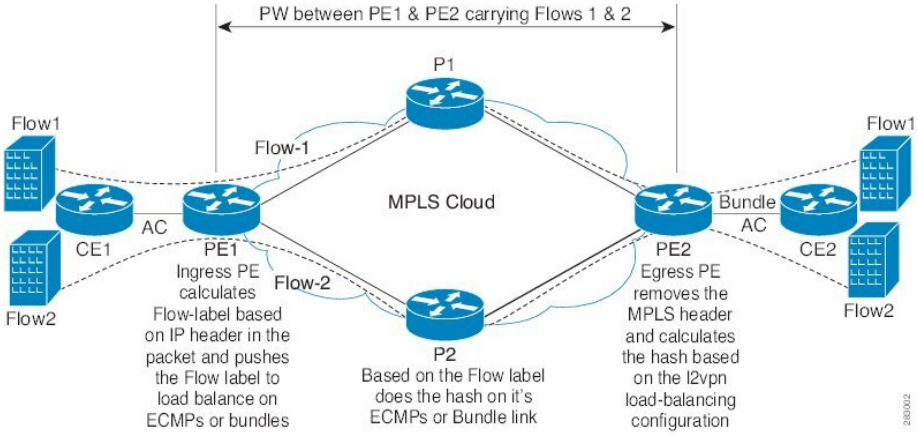
Flow Aware Transport Pseudowire (FAT PW)

Routers typically loadbalance traffic based on the lower most label in the label stack which is the same label for all flows on a given pseudowire. This can lead to asymmetric loadbalancing. The flow, in this context, refers to a sequence of packets that have the same source and destination pair. The packets are transported from a source provider edge (PE) to a destination PE.

Flow-Aware Transport Pseudowires (FAT PW) provide the capability to identify individual flows within a pseudowire and provide routers the ability to use these flows to loadbalance traffic. FAT PWs are used to loadbalance traffic in the core when equal cost multipaths (ECMP) are used. A flow label is created based on indivisible packet flows entering a pseudowire; and is inserted as the lower most label in the packet. Routers can use the flow label for loadbalancing which provides a better traffic distribution across ECMP paths or link-bundled paths in the core.

The following figure shows a FAT PW with two flows distributing over ECMPs and bundle links.

Figure 11: FAT PW with two flows distributing over ECMPs and Bundle-Links



An additional label is added to the stack, called the flow label, which contains the flow information of a virtual circuit (VC). A flow label is a unique identifier that distinguishes a flow within the PW, and is derived from source and destination MAC addresses, and source and destination IP addresses. The flow label contains the end of label stack (EOS) bit set and inserted after the VC label and before the control word (if any). The ingress PE calculates and forwards the flow label. The FAT PW configuration enables the flow label. The egress PE discards the flow label such that no decisions are made.

Core routers perform load balancing using the flow-label in the FAT PW with other information like MAC address and IP address. The flow-label adds greater entropy to improve traffic load balancing. Therefore, it's possible to distribute flows over ECMPs and link bundles.

You cannot send MPLS OAM ping traffic over a FAT PW, since there is no flow label support for MPLS OAM.

Pseudowire Headend

Table 3: Feature History Table

Feature Name	Release Information	Feature Description
PW Headend - GIL interface scale enhancement from 8 to 32	Release 7.3.1	This feature is now enhanced to support the maximum number of interfaces per generic interface list from 8 to 32 L3 physical interfaces.

Pseudowires (PWs) enable payloads to be transparently carried across IP/MPLS packet-switched networks (PSNs). PWs are regarded as simple and manageable lightweight tunnels for returning customer traffic into

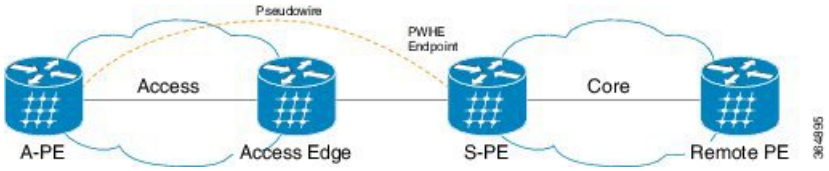
core networks. Service providers are now extending PW connectivity into the access and aggregation regions of their networks.

Pseudowire Headend (PWHE) is a technology that allows termination of access pseudowires (PWs) into a Layer 3 (VRF or global) domain or into a Layer 2 domain. PWs provide an easy and scalable mechanism for tunneling customer traffic into a common IP/MPLS network infrastructure. PWHE allows customers to provision features such as QOS access lists (ACL), L3VPN on a per PWHE interface basis, on a service Provider Edge (PE) router.

Note Encapsulation default is not supported by PWHE.

Consider the following network topology as an example.

Figure 12: Pseudowire Network



For PWHE x-connect configuration, interconnectivity between A-PE (Access Provider Edge) and S-PE is through BGP RFC3107 that distributes MPLS labels along with IP prefixes. The customer network can avoid using an IGP to provide connectivity to the S-PE device, which is outside the customer's autonomous system.

For all practical purposes, the PWHE interface is treated like any other existing L3 interface. PWs operate in one of the following modes:

- Bridged interworking (VC type 5 or VC type 4)
- IP interworking mode (VC type 11)

With VC type 4 and VC type 5, PWs carry customer Ethernet frames (tagged or untagged) with IP payload. Thus, an S-PE device must perform ARP resolution for customer IP addresses learned over the PWHE. With VC type 4 (VLAN tagged) and VC type 5 (Ethernet port/raw), PWHE acts as a broadcast interface. Whereas with VC type 11 (IP Interworking), PWHE acts as a point-to-point interface. Therefore there are two types of PWHE interface—PW-Ether (for VC type 4 and 5) and PW-IW (for VC type 11). These PWs can terminate into a VRF or the IP global table on S-PE.

Benefits of PWHE

Some of the benefits of implementing PWHE are:

- dissociates the customer facing interface (CFI) of the service PE from the underlying physical transport media of the access or aggregation network
- reduces capex in the access or aggregation network and service PE
- distributes and scales the customer facing Layer 2 UNI interface set
- implements a uniform method of OAM functionality
- providers can extend or expand the Layer 3 service footprints
- provides a method of terminating customer traffic into a next generation network (NGN)

Restrictions

- PWHE over 2nd level BGP Labeled Unicast (LU) recursion (BGP RFC3107) supports only if there's a single BGP path to a destination.
- PHWE doesn't support BGP Prefix Independent Convergence (PIC) backup paths.
- PWHE can support only a single BGP Next-hop to pseudowire destination.
- PWHE supports up to one level of BGP recursion.
- PHWE cannot exceed more than eight Generic Interface Lists (GILs) through the same IGP peer, with the same or different GIL members, in the case of A-PE reachable through BGP.
- PHWE cannot exceed more than eight Generic Interface Lists (GILs) in the case of A-PE reachable through IGP.
- If you're running IGP to reach PWHE neighbor (A-PE), then we can apply the same GIL name on multiple PWHE.

Generic Interface List

A generic interface list contains is a list of physical or bundle interfaces that is used in a PW-HE connection.

The generic interface list supports only main interfaces, and not sub-interfaces. The generic interface list is bi-directional and restricts both receive and transmit interfaces on access-facing line cards. The generic interface list has no impact on the core-facing side.

A generic interface list is used to limit the resources allocated for a PWHE interface to the set of interfaces specified in the list.

Only the S-PE is aware of the generic interface list and expects that the PWHE packets arrive on only line cards with generic interface list members on it. If packets arrive at the line card without generic interface list members on it, they are dropped.

Starting with Cisco IOS XR Software Release 7.3.1, the maximum number of interfaces per generic interface list is increased to 32 L3 physical interfaces. A maximum of eight L3 bundle interfaces is still supported. Furthermore, if there are more than eight interfaces under one of the generic interface lists, the supported number of generic interface list per IGP peer is reduced from eight to two.

Configure only those Layer 3 interfaces, either Bundle-Ether or physical, that are part of the generic interface list (GIL) through which PWHE connects access PE devices. PWHE does not support any Layer 2 interface or bundle member interfaces of the L3 interfaces list or L3VPN core-facing L3 interfaces.

However, the device still allows you to associate individual bundle member interfaces that are not part of the generic interface list (GIL). PWHE interfaces are up, and correspondingly all Xconnect configured on PWHE interfaces are up. But the traffic does not flow due to an undetected misconfiguration.

LFA over Pseudowire Headend

From Release 5.1.1, PW-HE is supported on loop free alternate (LFA) routes.

For LFA to be effective on a PW-HE interface, all the routing paths (protected and backup) must be included in the generic interface list of that PW-HE interface. If all the routing paths are not included in the generic interface list, then there may be loss of traffic even if LFA is enabled. This is because the LFA route could be the one that was not included in the generic interface list.

To configure LFA on PW-HE interface, do the following:

1. Configuring Generic Interface List
2. Configuring IP/LDP Fast Reroute

For more information about configuring the IP Fast Reroute Loop-free alternate, see Implementing IS-IS on Cisco IOS XR Software module of the *Cisco ASR 9000 Series Aggregation Services Router Routing Configuration Guide.*

PW-HE Multicast

Multicast support for Pseudowire Head-end (PW-HE) interfaces is available only on the enhanced ethernet cards.

For more information about PW-HE multicast feature, see the *Implementing Layer 3 Multicast Routing* chapter in the *Cisco ASR 9000 Series Aggregation Services Router Multicast Configuration Guide, Release 5.1.x*.

PW-HE over MPLS-TE Tunnels

The PW-HE over MPLS-TE Tunnels feature supports forwarding of pseudowire traffic (with pseudowire headend) over TE tunnels.

For more information about PW-HE over MPLS TE Tunnels, see the *Implementing MPLS Traffic Engineering* chapter in the *Cisco ASR 9000 Series Aggregation Services Router MPLS Configuration Guide, Release 5.1.x*.

PWHE Load Balancing Support using FAT Label

The PWHE Load Balancing Support using FAT Label feature enables flow hashing based load balancing across egress interfaces defined in the generic interface list. This feature also enables Flow Aware Transport (FAT) label that can be utilized for load balancing by downstream P-routers.

For load balancing among the members of the generic interface list, a five-tuple hash that includes source IP address, source port, destination IP address, destination port, and Router ID is utilized to distribute traffic among the members of the generic interface list.

You can insert the FAT label after successful negotiation with the remote router, or after static configuration. The downstream router uses it to perform load balancing. In Cisco IOS Software Release 6.6.1, only targeted-LDP signaling is supported to negotiate flow label.

Restrictions

- To implement the PWHE Load Balancing feature, use the Cisco ASR 9000 3rd generation line cards as your S-PE node ingress and egress line cards, because line card support is limited to only the 3rd generation.
- Flow labels are not supported when the incoming traffic is from an L2 transport PWHE interface (From Core to S-PE).
- Load balancing is not supported for MPLS-TE/TE preferred path.
- Enabling PWHE per-flow load balancing results in QoS behavior that is identical to multi-member bundles. A QoS policy instance is independently applied to each generic interface.

  Until Cisco IOS XR Software Release 6.6.1, only PW label hashing was supported, and absolute rate egress shaping and QoS could be configured. From Release 6.6.1, you can do one of the following:

  - Preserve the existing QoS accuracy without changing the load balancing mode.

  - Configure flow-based load balancing to take advantage of ECMP links at the detriment of absolute rate egress shaping and QoS.

- Configuring the **load-balancing flow src-dst-mac** command has the same effect as configuring **load-balancing flow src-dst-ip** command.
- This feature is not supported on PW-IW (VC type 11) interface.
- PWHE per-flow load-balancing is supported over L3 PW-Ethernet interfaces and sub-interfaces in L3, L3VPN and BNG deployment scenarios.
- PWHE per-flow load-balancing is not supported in EVPN, SR-TE and SR deployment scenarios.

Configure PWHE Load Balancing Support using FAT Label

This section describes how to configure PWHE load balancing using FAT label.

Configuration Example

Perfrom these tasks to configure PWHE load balancing using FAT label at both S-PE and A-PE.

S-PE Configuration

Perform these tasks at S-PE:

- Configure PWHE Ethernet interface and attach the generic interface list with a PWHE Ethernet interface.
- Configure global L2VPN load balancing (optional)
- Configure flow label
- Configure PWHE cross-connect

```
/* S-PE Configuration */

/* Configure PWHE Ethernet interface and attach the generic interface list with a PWHE
Ethernet interface */

RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# generic-interface-list gil1
RP/0/RSP0/CPU0:router(config-gen-if-list)# interface tenGigE 0/0/0/0/0
RP/0/RSP0/CPU0:router(config-gen-if-list)# interface tenGigE 0/1/0/1/0
RP/0/RSP0/CPU0:router(config-gen-if-list)# interface tenGigE 0/0/0/0/2
RP/0/RSP0/CPU0:router(config-gen-if-list)# exit
RP/0/RSP0/CPU0:router(config)# interface pw-ether 100
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 192.0.2.1/24
RP/0/RSP0/CPU0:router(config-if)# ipv6 address 2001:DB8::1/32
RP/0/RSP0/CPU0:router(config-if)# attach generic-interface-list gil1

/* Configure global L2VPN load balancing (Optional) */

RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)# load-balancing flow src-dst-ip

/* This enables flow-based load balancing across generic interface list members. */

/* Configure flow label */

RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# l2vpn
```

```
RP/0/RSP0/CPU0:router(config-l2vpn)# pw-class flow_lb_both
RP/0/RSP0/CPU0:router(config-l2vpn-pwc)# encapsulation mpls
RP/0/RSP0/CPU0:router(config-l2vpn-pwc-mpls)# load-balancing flow-label both

/* Configure PWHE cross-connect */

RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group pwhe_fat
RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p xc_main_interface
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface PW-Ether100
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# neighbor ipv4 209.165.200.225 pw-id 100
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# pw-class flow_lb_both
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# commit
```

A-PE Configuration

Perform these tasks at A-PE:

- Configure Ethernet L2 transport interface
- Configure flow label
- Configure PWHE cross-connect

```
/* A-PE Configuration */

/* Configure Ethernet L2 transport interface  */

RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface tenGigE 0/7/0/9.100 l2transport
RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 100
RP/0/RSP0/CPU0:router(config-subif)# rewrite ingress tag pop 1 symmetric

/* Configure flow label */

RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)# pw-class flow_lb_both
RP/0/RSP0/CPU0:router(config-l2vpn-pwc)# encapsulation mpls
RP/0/RSP0/CPU0:router(config-l2vpn-pwc-mpls)# load-balancing flow-label both

/* Configure PWHE cross-connect */

RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group pwhe_fat
RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p xc_main_intf
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface tenGigE 0/7/0/9.100
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# neighbor ipv4 209.165.201.1
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# pw-class flow_lb_both
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# commit
```

Running Configuration

This section shows PWHE load balancing using FAT label running configuration.

```
/* On S-PE */

/* Configure PWHE Ethernet interface and attach the generic interface list with a PWHE
Ethernet interface */
```

```
generic-interface-list gil1
 interface TenGigE0/0/0/0/0
 interface TenGigE0/0/0/0/2
 interface TenGigE0/1/0/1/0
!

interface PW-Ether100
 ipv4 address 192.0.2.1 255.255.255.0
 ipv6 address 2001:DB8::1/32
  attach generic-interface-list gil1
!

/* Configure global L2VPN load balancing */

l2vpn
 load-balancing flow src-dst-ip
!

/* Configure flow label */

l2vpn
 pw-class flow_lb_both
  encapsulation mpls
   load-balancing flow-label both
   !
  !

/* Configure PWHE cross-connect */

l2vpn
 xconnect group pwhe_fat
  p2p xc_main_interface
   interface PW-Ether100
   neighbor ipv4 209.165.200.225 pw-id 100
    pw-class flow_lb_both
   !
  !
!
```

```
/* On A-PE */

/* Configure Ethernet L2 transport interface */

interface TenGigE0/7/0/9.100 l2transport
 encapsulation dot1q 100
rewrite ingress tag pop 1 symmetric
!

/* Configure flow label */

l2vpn
 pw-class flow_lb_both
  encapsulation mpls
   load-balancing flow-label both
   !

/* Configure PWHE cross-connect */

l2vpn
 xconnect group pwhe_fat
  p2p xc_main_intf
   interface TenGigE0/7/0/9.100
```

```
   neighbor ipv4 209.165.201.1 pw-id 100
    pw-class flow_lb_both
   !
  !
```

Verification

The show output given in the following section display the details of the configuration of PWHE Ethernet interface, PWHE cross-connect, flow label, load balancing and the status of their configuration .

```
RP/0/RSP0/CPU0:router#show l2vpn xconnect pw-id 100 detail

Group pwhe_fat, XC xc_main_interface, state is up; Interworking none
  AC: PW-Ether100, state is up
    Type PW-Ether
    Interface-list: gil1
    Replicate status:
    Te0/0/0/0/0: success
    Te0/0/0/0/2: success
    Te0/1/0/1/0: success
    MTU 1500; interworking none
    Internal label: 232235
    Statistics:
      packets: received 0, sent 0
      bytes: received 0, sent 0
  PW: neighbor 209.165.200.225, PW ID 100, state is up ( established )
    PW class flow_lb_both, XC ID 0xa0000013
    Encapsulation MPLS, protocol LDP
    Source address 209.165.201.1
    PW type Ethernet, control word disabled, interworking none
    PW backup disable delay 0 sec
    Sequencing not set
    LSP : Up
    Load Balance Hashing: src-dst-ip
    Flow Label flags configured (Tx=1,Rx=1), negotiated (Tx=1,Rx=1)

    PW Status TLV in use
      MPLS         Local                          Remote
      ------------ ------------------------------ ------------------------------
      Label        28130                          24114
      Group ID     0x40406e0                      0x12000300
      Interface    PW-Ether100                    TenGigE0/7/0/9.100
      MTU          1500                           1500
      Control word disabled                       disabled
      PW type      Ethernet                       Ethernet
      VCCV CV type 0x2                            0x2
                   (LSP ping verification)        (LSP ping verification)
      VCCV CC type 0x6                            0x6
                   (RP/0/RSP0/CPU0:router alert label)           (RP/0/RSP0/CPU0:router
alert label)
                   (TTL expiry)                   (TTL expiry)
      ------------ ------------------------------ ------------------------------
    Incoming Status (PW Status TLV):
      Status code: 0x0 (Up) in Notification message
    Outgoing Status (PW Status TLV):
      Status code: 0x0 (Up) in Notification message
    MIB cpwVcIndex: 2684354579
    Create time: 25/09/2018 15:02:44 (1d04h ago)
    Last time status changed: 26/09/2018 18:07:25 (01:41:29 ago)
    Last time PW went down: 26/09/2018 17:45:25 (02:03:28 ago)
    Statistics:
      packets: received 0, sent 0
```

```
bytes: received 0, sent 0
```

Related Topics

- Flow Aware Transport Pseudowire (FAT PW) , on page 29
- Pseudowire Headend, on page 30

Associated Commands

- load-balancing flow
- xconnect group
- show l2vpn xconnect

MVPN Profile 26 for Pseudowire Headend

The MVPN Profile 26 for Pseudowire Headend feature adds support for multicast VPN (MVPN) profile 26 on pseudowire headend (PWHE) interface to provide multicast services. Profile 26 is a next-generation MVPN profile that carries multicast traffic encapsulated in MPLS packets. The traffic is forwarded with MPLS labels using Point-to-Multipoint (P2MP) MPLS Traffic Engineering (TE) as the core signaling protocol. BGP is used as the overlay signaling protocol for partitioned multicast distribution trees (MDTs). Profile 26 represents partitioned-P2MP-TE with BGP C-multicast routing.

Some of the characteristics of this profile include:

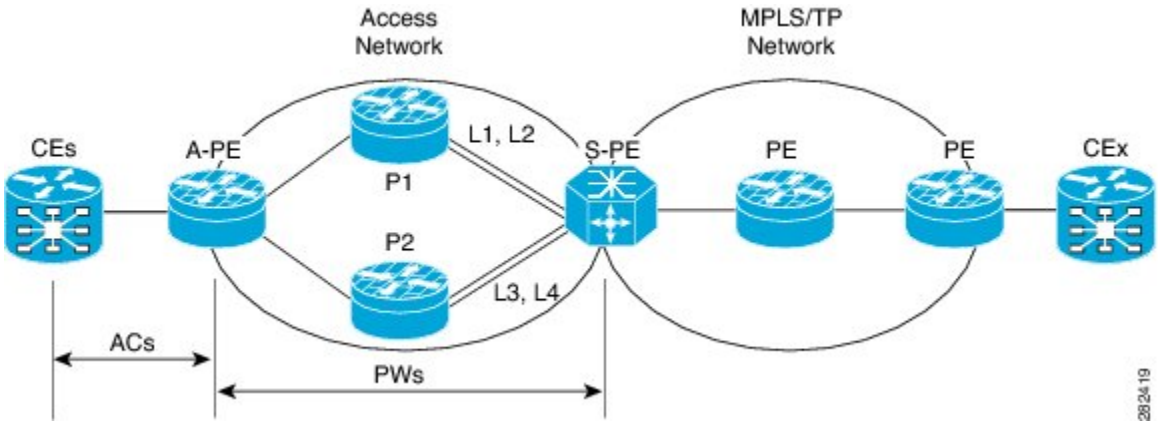
- Dynamic P2MP-TE tunnels with BGP C-multicast routing
- All Upstream Multicast Hop (UMH) options are supported
- Default and data MDT are supported
- Customer traffic can be SM or source-specific multicast (SSM)
- RIB-Extranet, RPL-Extranet, Hub and Spoke are supported
- Inter-AS option A and C are supported

Consider a topology where PWHE interfaces reside on the S-PE facing the access interface and is configured with the customer VRF. Access Pseudowires (PWs) from the A-PE of the Layer 2 domain terminate on this PWHE on the S-PE in to Layer 3 MVPN Profile 26 MPLS network. Psesudowire connectivity is established between A-PE and S-PE through cross-connect. Routing is established end-to-end through IGP protocols. The nodes are connected through MPLS core.

P2MP TE auto-tunnels are established dynamically when S-PE receives PIM Join message from the participating PE receivers.

Multicast traffic from the access side towards the PWHE interface on the S-PE travels across the MPLS core as encapsulated MPLS packets through P2MP TE auto-tunnels to the tail-end PEs. Similary, for multicast traffic with the sources from the L3 domain, tunnels are established with S-PE as the tail-end PE. The traffic is decapsulated in to the L2 domain to the access PE receivers.

Figure 13: MVPN Profile 26 for Pseudowire Headend



Partitioned MDT with BGP C-multicast Signaling

Partitioned MDT is an MDT between a subset of PE routers and an ingress PE router. Each egress PE router advertises itself by sending a Type 3 route. This BGP Type 3 route has wildcards, which indicates that it applies for any source and any group. The Type 3 route has the PTA indicating the core tree protocol to be used and the kind of tree. This type 3 route only indicates the possibility to become part of any partitioned MDT. No partitioned MDT is set up. When a PE receives a PIM Join for C-(S,G) , the PE performs a reverse path forwarding (RPF) lookup to find the BGP next-hop address. This PE joins the tree as indicated in the Type 3 route towards the root which is the BGP next-hop. The S-PE forwards the C-(S,G) traffic onto the tree.

With P2MP TE as the core tree protocol, the P2MP TE label switched-path (LSP) must be set up by the head-end link-state routing (LSR). In this case it is the ingress PE router. Egress PE routers nofitify the ingress PE that they would be tail end routers of a new P2MP TE, which is the partitioned MDT. Egress PE routers send a BGP AD Route Type 4 targetted at ingress PE. Ingress PE learns that there are two tail end routers for the new P2MP TE LSP and initiates the signaling of the P2MP TE LSP with RSVP. Ingress sends out path messages towards tail end routers. Egress PEs send back received messgaes towards the ingress PE. When this signaling is successful, the partitioned MDT comprising of a P2MP TE LSP, is set up.

To build up the partitioned MDT with P2MP TE, BGP-AD is used utilizing the address family IPv4 MVPN. This way each PE can become the MPLS TE head-end router of a P2MP MPLS TE tree or tunnel. Also, learn which routers are the tail-end routers, and proceed with the RSVP-TE signaling towards each of the tail-end routers. These tunnels are P2MP auto-tunnels that are provisioned automatically.

Configure MVPN Profile 26 for Pseudowire Headend

Perform the following tasks to configure MVPN Profile 26 for Pseudowire Headend feature:

S-PE Configuration

- Configure Profile 26
- Configure generic interface list
- Configure PWHE Ethernet and interworking interfaces, attach the generic interface list with a PWHE Ethernet and interworking interfaces
- Configure PW class for Ethernet and interworking interfaces

- Configure cross-connect using PWHE Ether and PWIW interfaces

```
/* S-PE Configuration */

/* Configure Profile 26 */
Router#configure
Router(config)#router pim
Router(config-pim)#vrf one
Router(config-pim-vrf1)#address-family ipv4
Router(config-pim-vrf1-ipv4)#rpf topology route-policy rpf-vrf-one
Router(config-pim-vrf1-ipv4)#mdt c-multicast-routing bgp`
Router(config-pim-vrf1-ipv4-md-cmcast)#exit
Router(config-pim-vrf1)#address-family ipv6
Router(config-pim-vrf1-ipv6)#rpf topology route-policy rpf-vrf-one
Router(config-pim-vrf1-ipv6)#mdt c-multicast-routing bgp
Router(config-pim-vrf1-ipv6-md-cmcast)#commit

Router(config)#interface GigabitEthernet
Router(config-if)#route-policy rpf-vrf-one
Router(config-rpl)#set core-tree p2mp-te-partitioned
Router(config-rpl)#end-policy


Router#configure
Router(config)#multicast-routing
Router(config-mcast)#vrf one
Router(config-mcast-vrf1)#address-family ipv4
Router(config-mcast-vrf1-ipv4)#rate-per-route
Router(config-mcast-vrf1-ipv4)#interface all enable`
Router(config-mcast-vrf1-ipv4)#accounting per-prefix
Router(config-mcast-vrf1-ipv4)#bgp auto-discovery p2mp-te
Router(config-mcast-vrf1-ipv4-bgp-ad)#mdt source Loopback0
Router(config-mcast-vrf1-ipv4-bgp-ad)#mdt partitioned p2mp-te 100
Router(config-mcast-vrf1-ipv4-bgp-ad)#exit

Router(config-mcast-vrf1)#address-family ipv6
Router(config-mcast-vrf1-ipv6)#rate-per-route
Router(config-mcast-vrf1-ipv6)#interface all enable`
Router(config-mcast-vrf1-ipv6)#accounting per-prefix
Router(config-mcast-vrf1-ipv6)#bgp auto-discovery p2mp-te
Router(config-mcast-vrf1-ipv6-bgp-ad)#mdt source Loopback0
Router(config-mcast-vrf1-ipv6-bgp-ad)#mdt partitioned p2mp-te 100
Router(config-mcast-vrf1-ipv6-bgp-ad)#commit

/* Configure generic interface list for PWHE Ethernet interface */

Router# configure
Router(config)# generic-interface-list pwhe-list-APE2-1
Router(config-gen-if-list)# interface Bundle-Ether200
Router(config-gen-if-list)# interface TenGigE0/0/0/0/4
Router(config-gen-if-list)# interface TenGigE0/0/0/0/5


/* Configure PWHE Ethernet interface and attach the generic interface list with a PWHE
Ethernet interface */

Router# configure
Router(config)# interface pw-ether 5001
Router(config-if)# ipv4 address 103.7.7.1 255.255.255.252
Router(config-if)# ipv6 address 103:107:1::1/126
Router(config-if)# attach generic-interface-list pwhe-list-APE2-1
```

```
/* Configure generic interface list for PW interworking interface */

Router# configure
Router(config)# generic-interface-list pwhe-list-APE-2
Router(config-gen-if-list)# interface Bundle-Ether201
Router(config-gen-if-list)# interface TenGigE0/0/0/0/6
Router(config-gen-if-list)# interface TenGigE0/0/0/0/7


/* Configure interworking interface and attach the generic interface list with an interworking
 interface */

Router# configure
Router(config)#  interface pw-iw 4001
Router(config-if)# ipv4 address 103.107.47.225 255.255.255.252
Router(config-if)# attach generic-interface-list pwhe-list-APE-2


/* Configure PW class for Ethernet interface */

Router# configure
Router(config)# l2vpn
Router(config-l2vpn)#  pw-class APE2-PE1-PORT
Router(config-l2vpn-pwc)# encapsulation mpls
Router(config-l2vpn-pwc-mpls)# control-word
Router(config-l2vpn-pwc-mpls)# transport-mode ethernet


/* Configure cross-connect for PW Ethernet interface */

Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# xconnect group APE2-PE1-PORT
Router(config-l2vpn-xc)# p2p APE2-PE1-5001
Router(config-l2vpn-xc-p2p)# interface PW-Ether5001
Router(config-l2vpn-xc-p2p-pw)# neighbor ipv4 100.1.8.1 pw-id 5001
Router(config-l2vpn-xc-p2p-pw)# pw-class APE2-PE1-PORT


/* Configure PW class for interworking interface */

Router# configure
Router(config)# l2vpn
Router(config-l2vpn)#  pw-class APE-InetRI-PWIW-4001
Router(config-l2vpn-pwc)# encapsulation mpls
Router(config-l2vpn-pwc-mpls)# control-word


/* Configure cross-connect for PW interworking interface */

Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# xconnect group APE-InetRI-PWIW-4001
Router(config-l2vpn-xc)# p2p APE-InetRI-PWIW-4001
Router(config-l2vpn-xc-p2p)# interface PW-IW4001
Router(config-l2vpn-xc-p2p-pw)# neighbor ipv4 100.1.9.1 pw-id 4001
Router(config-l2vpn-xc-p2p-pw)# pw-class APE-InetRI-PWIW-4001
Router(config-l2vpn-xc-p2p-pw)# interworking ipv4
```

A-PE Configuration

- Configure PWHE Ethernet and interworking interfaces, attach the generic interface list with a PWHE Ethernet and interworking interfaces
- Configure PW class for Ethernet and interworking interfaces
- Configure cross-connect using PWHE Ether and PWIW interfaces

```
/* A-PE Configuration */

/* Configure PWHE  Ethernet interface */

Router# configure
Router(config)# interface TenGigE0/0/0/0 l2transport
Router(config-subif)# encapsulation dot1q 1001
Router(config-subif)# rewrite ingress tag pop 1 symmetric


/* Configure interworking interface */

Router# configure
Router(config)# interface Serial0/5/0/0/8 l2transport



/* Configure PW Class for Ethernet interface */

Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# pw-class APE2-PE1-PORT
Router(config-l2vpn-pwc)# encapsulation mpls
Router(config-l2vpn-pwc-mpls)# control-word
Router(config-l2vpn-pwc-mpls)# transport-mode ethernet


/* Configure Cross-connect for Ethernet interface */

Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# xconnect group APE2-PE1-PORT
Router(config-l2vpn-xc)# p2p APE2-PE1-5001
Router(config-l2vpn-xc-p2p)# interface TenGigE0/0/0/0
Router(config-l2vpn-xc-p2p-pw)# neighbor ipv4 100.1.1.1 pw-id 5001
Router(config-l2vpn-xc-p2p-pw)# pw-class APE2-PE1-PORT


/* Configure PW Class for interworking interface */

Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# pw-class APE-InetRI-PWIW-4001
Router(config-l2vpn-pwc)# encapsulation mpls
Router(config-l2vpn-pwc-mpls)# control-word



/* Configure Cross-connect for interworking interface */

Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# xconnect group APE-InetRI-PWIW-4001
Router(config-l2vpn-xc)# p2p APE-InetRI-PWIW-4001
Router(config-l2vpn-xc-p2p)# interface Serial0/5/0/0/8
```

```
Router(config-l2vpn-xc-p2p-pw)# neighbor ipv4 100.1.1.1 pw-id 4001
Router(config-l2vpn-xc-p2p-pw)# pw-class APE-InetRI-PWIW-4001
Router(config-l2vpn-xc-p2p-pw)# interworking ipv4
```

Running Configuration

This section shows MVPN Profile 26 for Pseudowire Headend running configuration.

```
/* On S-PE */

/* Profile 26 */
vrf one
  address-family ipv4
   rpf topology route-policy rpf-vrf-one
   mdt c-multicast-routing bgp
   !
  address-family ipv6
   rpf topology route-policy rpf-vrf-one
   mdt c-multicast-routing bgp
   !

interface GigabitEthernet
 route-policy rpf-vrf-one
  set core-tree p2mp-te-partitioned
end-policy

multicast-routing
 vrf one
  address-family ipv4
   rate-per-route
   interface all enable
   accounting per-prefix
   bgp auto-discovery p2mp-te
    mdt source Loopback0
    mdt partitioned p2mp-te 100
    !
   !
  address-family ipv6
   rate-per-route
   interface all enable
   accounting per-prefix
   bgp auto-discovery p2mp-te
    mdt source Loopback0
    mdt partitioned p2mp-te 100

/* Ethernet interface */

configure
 generic-interface-list pwhe-list-APE2-1
  interface Bundle-Ether200
  interface TenGigE0/0/0/0/4
  interface TenGigE0/0/0/0/5
  !
!

configure
 interface PW-Ether5001
  ipv4 address 103.107.1.1 255.255.255.252
  ipv6 address 103:107:1::1/126
  attach generic-interface-list pwhe-list-APE2-1

!
```

```
l2vpn
 pw-class APE2-PE1-PORT
  encapsulation mpls
   control-word
   transport-mode ethernet
  !

!

l2vpn
 xconnect group APE2-PE1-PORT
  p2p APE2-PE1-5001
   interface PW-Ether5001
   neighbor ipv4 100.1.8.1 pw-id 5001
    pw-class APE2-PE1-PORT



/* Interworking interface */

configure
 generic-interface-list pwhe-list-APE-2
  interface Bundle-Ether200
  interface TenGigE0/0/0/0/6
  interface TenGigE0/0/0/0/7
  !
!


configure
 interface PW-IW4001
  ipv4 address 103.107.47.225 255.255.255.252
  attach generic-interface-list pwhe-APE-2

!

l2vpn
 pw-class APE-InetRI-PWIW-4001
  encapsulation mpls
   control-word
   !
!

l2vpn
 xconnect group APE-InetRI-PWIW-4001
  p2p APE-InetRI-PWIW-4001
   interface PW-IW4001
   neighbor ipv4 100.1.9.1 pw-id 4001
    pw-class APE-InetRI-PWIW-4001
    !
    interworking ipv4
    !
  !

 !
```

```
/* On A-PE */

/* Ethernet interface */

configure
 interface TenGigE0/0/0/0 l2transport
```

```
  encapsulation dot1q 1001
  rewrite ingress tag pop 1 symmetric
!

l2vpn
 pw-class APE2-PE1-PORT
  encapsulation mpls
   control-word
   transport-mode ethernet
  !
!

l2vpn
 xconnect group APE2-PE1-PORT
  p2p APE2-PE1-5001
   interface TenGigE0/0/0/0
   neighbor ipv4 100.1.1.1 pw-id 5001
    pw-class APE2-PE1-PORT
   !
!


/* Interworking interface */

configure
 interface Serial0/5/0/0/8 l2transport
 !
!

l2vpn
 pw-class APE-InetRI-PWIW-4001
  encapsulation mpls
  control-word
  !
!

l2vpn
 xconnect group APE-InetRI-PWIW-4001
  p2p APE-InetRI-PWIW-4001
   interface Serial0/5/0/0/8
   neighbor ipv4 100.1.1.1 pw-id 4001
   pw-class APE-InetRI-PWIW-4001
   !
   interworking ipv4
   !
  !
```

Verification

The show outputs given in the following section display the details of the configuration of PW Ethernet interface and cross-connect, and the status of their configuration on S-PE and A-PE.

```
/* S-PE Configuration */

Router-S-PE#  show l2vpn xconnect interface pw-ether 5001 detail
Group APE2-PE1-PORT, XC APE2-PE1-5001, state is up; Interworking none
  AC: PW-Ether5001, state is up
    Type PW-Ether
    Interface-list: pwhe-list-APE2-1
    Replicate status:
    BE616: success
```

```
    BE617: success
    MTU 8986; interworking none
    Internal label: 25002
    Statistics:
      packets: received 96860, sent 101636
      bytes: received 7285334, sent 8703696
  PW: neighbor 100.1.8.1, PW ID 5001, state is up ( established )
    PW class APE2-PE1-PORT, XC ID 0xfffe07d0
    Encapsulation MPLS, protocol LDP
    Source address 100.1.1.1
    PW type Ethernet, control word disabled, interworking none
    PW backup disable delay 0 sec
    Sequencing not set

    PW Status TLV in use
      MPLS         Local                          Remote
      ------------ ------------------------------ ------------------------------
      Label        29012                          24001
      Group ID     0x4607d3c                      0x40000c0
      Interface    PW-Ether5001                   TenGigE0/0/0/0
      MTU          8986                           8986
      Control word disabled                       disabled
      PW type      Ethernet                       Ethernet
      VCCV CV type 0x2                            0x2
                   (LSP ping verification)        (LSP ping verification)
      VCCV CC type 0x6                            0x6
                   (router alert label)           (router alert label)
                   (TTL expiry)                   (TTL expiry)
      ------------ ------------------------------ ------------------------------
    Incoming Status (PW Status TLV):
      Status code: 0x0 (Up) in Notification message
    Outgoing Status (PW Status TLV):
      Status code: 0x0 (Up) in Notification message
    MIB cpwVcIndex: 4294838224
    Create time: 26/09/2017 11:08:57 (18:23:34 ago)
    Last time status changed: 26/09/2017 11:28:59 (18:03:32 ago)
    Statistics:
      packets: received 96860, sent 101636
      bytes: received 7285334, sent 8703696
```

```
/* A-PE configuration details */

Router-A-PE# show l2vpn xconnect interface te0/0/0/0 detail
Group APE2-PE1-PORT, XC APE2-PE1-5001, state is up; Interworking none
  AC: TenGigE0/0/0/0, state is up
    Type Ethernet
    MTU 8986; XC ID 0x1084455; interworking none
    Statistics:
      packets: received 399484457, sent 1073874787256
      bytes: received 42812068782, sent 81549786107821
  PW: neighbor 100.1.1.1, PW ID 5001, state is up ( established )
    PW class APE2-PE1-PORT, XC ID 0xc0000fa1
    Encapsulation MPLS, protocol LDP
    Source address 100.1.8.1
    PW type Ethernet, control word disabled, interworking none
    PW backup disable delay 0 sec
    Sequencing not set

    PW Status TLV in use
      MPLS         Local                          Remote
      ------------ ------------------------------ ------------------------------
```

```
    Label        24001                          29012
    Group ID     0x40000c0                      0x4607d3c
    Interface    TenGigE0/0/0/0                 PW-Ether5001
    MTU          8986                           8986
    Control word disabled                       disabled
    PW type      Ethernet                       Ethernet
    VCCV CV type 0x2                            0x2
                 (LSP ping verification)        (LSP ping verification)
    VCCV CC type 0x6                            0x6
                 (router alert label)           (router alert label)
                 (TTL expiry)                   (TTL expiry)
    ------------ ------------------------------ ------------------------------
  Incoming Status (PW Status TLV):
    Status code: 0x0 (Up) in Notification message
  Outgoing Status (PW Status TLV):
    Status code: 0x0 (Up) in Notification message
  MIB cpwVcIndex: 3221229473
  Create time: 04/09/2017 17:48:35 (3w1d ago)
  Last time status changed: 26/09/2017 23:37:11 (18:01:16 ago)
  Last time PW went down: 26/09/2017 23:21:53 (18:16:34 ago)
  Statistics:
    packets: received 1073874787256, sent 399484457
    bytes: received 81549786107821, sent 42812068782
```

The show outputs given in the following section display the details of the configuration of PW interworking interface and cross-connect, and the status of their configuration on S-PE and A-PE.

```
/* S-PE Configuration */

Router-S-PE#  show l2vpn xconnect interface pw-iw 4001 detail
Group APE-InetRI-PWIW-4001, XC APE-InetRI-PWIW-4001, state is up; Interworking IPv4
  AC: PW-IW4001, state is up
    Type PW-IW
    Interface-list: pwhe-APE-2
    Replicate status:
    BE616: success
    MTU 4470; interworking IPv4
    Internal label: 35423
    Statistics:
      packets: received 185986, sent 185985
      bytes: received 134084287, sent 134654943
  PW: neighbor 100.1.9.1, PW ID 4001, state is up ( established )
    PW class APE-InetRI-PWIW-4001, XC ID 0xfffe1058
    Encapsulation MPLS, protocol LDP
    Source address 100.1.1.1
    PW type IP, control word enabled, interworking IPv4
    PW backup disable delay 0 sec
    Sequencing not set

    PW Status TLV in use
      MPLS         Local                          Remote
      ------------ ------------------------------ ------------------------------
      Label        152284                         24018
      Group ID     0x84003ed4                     0xe004040
      Interface    PW-IW4001                      Serial0/5/0/0/8
      MTU          4470                           4470
      Control word enabled                        enabled
      PW type      IP                             IP
      VCCV CV type 0x2                            0x2
                   (LSP ping verification)        (LSP ping verification)
      VCCV CC type 0x7                            0x7
```

```
                  (control word)                (control word)
                  (router alert label)          (router alert label)
                  (TTL expiry)                  (TTL expiry)
      ------------ ------------------------------ ------------------------------
    Incoming Status (PW Status TLV):
      Status code: 0x0 (Up) in Notification message
    Outgoing Status (PW Status TLV):
      Status code: 0x0 (Up) in Notification message
    MIB cpwVcIndex: 4294840408
    Create time: 04/10/2017 09:55:04 (00:21:36 ago)
    Last time status changed: 04/10/2017 10:02:45 (00:13:56 ago)
    Statistics:
      packets: received 185986, sent 185985
      bytes: received 134084287, sent 134654943
```

```
/* A-PE configuration details */

Router-A-PE# show interface pw-iw 4001
PW-IW4001 is up, line protocol is up
  Interface state transitions: 1
  Hardware is PWHE VC11 IP Interworking Interface
  Internet address is 103.107.47.225/30
  MTU 4470 bytes, BW 10000 Kbit (Max: 10000 Kbit)
     reliability 255/255, txload 7/255, rxload 7/255
  Encapsulation PW-IW,  loopback not set,
  Last link flapped 00:14:44
    L2Overhead: 0
    Generic-Interface-List: pwhe-APE-2
  Last input 00:11:04, output 00:11:04
  Last clearing of "show interface" counters never
  5 minute input rate 277000 bits/sec, 48 packets/sec
  5 minute output rate 293000 bits/sec, 51 packets/sec
     185986 packets input, 134084287 bytes, 0 total input drops
     0 drops for unrecognized upper-level protocol
     Received 0 broadcast packets, 0 multicast packets
     185985 packets output, 134654943 bytes, 0 total output drops
     Output 0 broadcast packets, 0 multicast packets
```

The show output given in the following section display the details of the configuration of PWHE subinterface.

```
Router# show interface pw-ether 5001.1001
PW-Ether5001.1001 is up, line protocol is up
  Interface state transitions: 1
  Hardware is VLAN sub-interface(s), address is ac19.7200.0001
  Internet address is 105.1.1.1/30
  MTU 9004 bytes, BW 10000 Kbit (Max: 10000 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation 802.1Q Virtual LAN, VLAN Id 1001,  loopback not set,
  Last link flapped 00:14:56
  ARP type ARPA, ARP timeout 04:00:00
  Last input 00:00:00, output 00:00:00
  Last clearing of "show interface" counters never
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 1000 bits/sec, 0 packets/sec
     196 packets input, 15554 bytes, 1282 total input drops
     0 drops for unrecognized upper-level protocol
     Received 0 broadcast packets, 0 multicast packets
     1416 packets output, 923195 bytes, 3 total output drops
     Output 0 broadcast packets, 15 multicast packets
```

DHCP on PWHE Interfaces

The DHCP on PWHE interfaces feature enables you to configure the DHCP functionality, such as DHCP server, relay, or proxy on the PWHE interface.

This feature allows you to offer LAN IP gateway services, such as, DHCP and DNS to your customers connected through PWHE interface. This feature removes the need for an extra layer 3 router at your branch site. Instead, use S-PE to centralize the DHCP-server functionality to lower the cost and simplify on-premise solution. This feature minimizes the equipment needed on-premise at the end-customer premises. Centralizing DHCP on the S-PE allows you to offer faster time-to-market because you do not have to ship layer 3 devices to your customer site. This feature significantly simplifies the connectivity of enterprise branch sites requiring LAN DHCP services from their service provider.

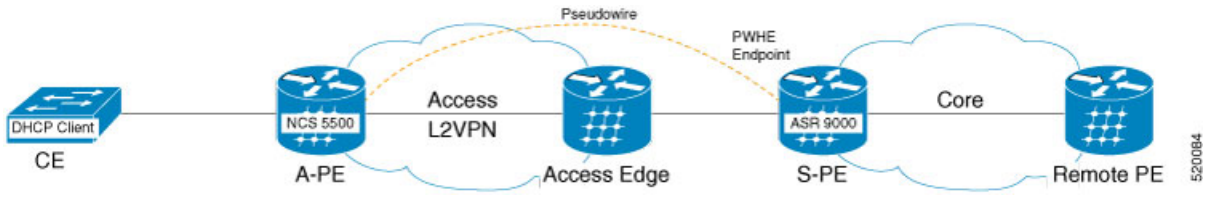
This feature is supported only on 64-bit IOS XR operating system.

Consider a topology where an NCS 5500 router is facing the access side, and an ASR 9000 router is facing the core side. Create a PWHE tunnel between these routers. The PWHE tunnel originates at L2 on the NCS 5500 router and terminates at L3 on the ASR 9000 router. Configure EVPN-VPWS cross-connect between the NCS 5500 router and the ASR 9000 router.

You can configure the ASR 9000 router as a DHCP server, relay, or proxy on the PWHE main interface or sub-interface.

The AC carries the traffic in its native form; that is, Ethernet frames with or without VLAN tagging, depending on whether you are creating a VLAN-based pseudowire or an Ethernet-based pseudowire.

Figure 14: DHCP Functionality for PWHE Interfaces



If you configure the ASR 9000 router as a DHCP server on the PWHE interface, it processes the request received from the DHCP client. The DHCP server accepts address assignment requests and renewals, and assigns the IP addresses from predefined groups of addresses contained within Distributed Address Pools (DAPS). You can also configure the DHCP server to provide additional information to the requesting client, such as subnet mask, domain-name, the IP address of the DNS server, the default router, and other configuration parameters.

If you configure the ASR 9000 router as a DHCP relay or proxy on the PWHE interface, it forwards the request received from the DHCP client to the remote server. The remote server processes the request and provides information back to the DHCP relay or proxy.

This feature supports both DHCP IPv4 and IPv6 addresses.

Configure DHCP on Pseudowire Headend

To configure DHCP on Pseudowire Headend feature, perform the following tasks:

- Configure PWHE on S-PE and A-PE
- Configure DHCP on S-PE

Configure PWHE on both S-PE and A-PE

This section describes how you can configure pseudowire headend on both S-PE and A-PE.

S-PE Configuration

```
/* S-PE Configuration */

Router# configure
Router(config)# generic-interface-list pwhe-list-pwhe2
Router(config-gen-if-list)# interface pw-ether 2
Router(config-gen-if-list)# exit
Router# configure
Router(config)# interface pw-ether 2
Router(config-if)# ipv4 address 10.0.0.1 255.0.0.0
Router(config-if)# attach generic-interface-list pwhe-list-pwhe2
Router(config-if)# exit
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# xconnect group evpn_vpws
Router(config-l2vpn-xc)# p2p vpws_1
Router(config-l2vpn-xc-p2p)# PW-Ether2
Router(config-l2vpn-xc-p2p-pw)# neighbor evpn evi 25 target 200 source 100
Router(config-l2vpn-xc-p2p-pw)# exit
Router(config)# generic-interface-list pwhe2
Router(config-gen-if-list)#  interface TenGigE0/1/0/1
```

A-PE Configuration

```
/* A-PE Configuration */

Router# configure
Router(config)# interface TenGigE0/0/0/0 l2transport
Router(config-subif)# encapsulation dot1q 1001
Router(config-subif)# rewrite ingress tag pop 1 symmetric
Router(config-subif)# exit
Router# configure
Router(config)# l2vpn
Router(config-l2vpn)# xconnect group evpn_vpws
Router(config-l2vpn-xc)# p2p vpws_1
Router(config-l2vpn-xc-p2p)# interface TenGigE0/0/0/21
Router(config-l2vpn-xc-p2p-pw)# neighbor evpn evi 25 target 100 source 200
```

Running Configuration

This section shows pseudowire headend running configuration.

```
/* On S-PE */

configure
 generic-interface-list pwhe-list-pwhe2
  interface pw-ether 2

  !

 interface pw-ether 2
  ipv4 address 10.0.0.1 255.0.0.0
  attach generic-interface-list pwhe-list-pwhe2

!


l2vpn
 xconnect group evpn_vpws
```

```
  p2p vpws_1
   interface PW-Ether2
   neighbor evpn evi 25 target 200 source 100
   !
generic-interface-list pwhe2
 interface TenGigE0/1/0/1
```

```
/* On A-PE */

configure
 interface TenGigE0/0/0/0 l2transport
  encapsulation dot1q 1001
  rewrite ingress tag pop 1 symmetric
!
!
l2vpn
 xconnect group evpn_vpws
  p2p vpws_1
   interface TenGigE0/0/0/21
   neighbor evpn evi 25 target 100 source 200
   !
!
```

Verification

The show command outputs given in this section display the details of the configuration of PW Ethernet interface and cross-connect, and the status of their configuration.

```
Router#  show l2vpn xconnect

Legend: ST = State, UP = Up, DN = Down, AD = Admin Down, UR = Unresolved,
        SB = Standby, SR = Standby Ready, (PP) = Partially Programmed

XConnect                   Segment 1                       Segment 2
Group      Name       ST   Description            ST       Description             ST
------------------------   ----------------------------   -----------------------------
evpn_vpws  vpws_1     UP   PE2                    UP       EVPN 25,172.16.0.1   UP
```

Configure DHCP on S-PE

You can configure the ASR 9000 series router as DHCP server, relay, or proxy on the PWHE main interface or sub-interface.

Configure DHCP Server

Perform these tasks to configure DHCP server on PWHE interface.

```
Router# configure
Router(config)# dhcp ipv4
Router(config-dhcpv4)# profile svr1 server
Router(config-dhcpv4-server-profile)# lease lease 0 1 0
Router(config-dhcpv4-server-profile)# pool pool_1
Router(config-dhcpv4-server-profile)# exit
```

```
Router(config-dhcpv4)# profile svr2 server
Router(config-dhcpv4-server-profile)# lease lease 0 1 0
Router(config-dhcpv4-server-profile)# pool pool_2
Router(config-dhcpv4-server-profile)# exit
Router(config-dhcpv4)#interface PW-Ether2.101 server profile SVR1
Router(config-dhcpv4)#interface PW-Ether2.102 server profile SVR2
Router(config-dhcpv4)#exit
Router(config)# pool vrf default ipv4 pool_1
Router(config-pool-ipv4)# address-range 10.0.0.1 10.255.255.254
Router(config-pool-ipv4)# exit
Router(config)# pool vrf default ipv4 pool_2
Router(config-pool-ipv4)# address-range 192.168.0.1 192.168.255.254
Router(config-pool-ipv4)# exit
```

Running Configuration

This section shows DHCP server running configuration.

```
configure
 dhcp ipv4
  profile SVR1 server
  lease 0 1 0
  pool pool_1
 !
  profile SVR2 server
  lease 0 1 0
  pool pool_2
 !

 !
 interface PW-Ether2.101 server profile SVR1
 interface PW-Ether2.102 server profile SVR2
```

Verification

Verify the DHCP server configuration.

```
Router#show dhcp ipv4 server binding
Wed Nov 20 13:09:11.579 IST
                                        Lease

 MAC Address      IP Address      State    Remaining       Interface          VRF
Sublabel
--------------  --------------  ---------  ---------  -------------------  ---------
----------
0010.9400.c02a  10.0.0.22        BOUND      3099       PE2.102              default    0x0

0010.9400.c02b  10.0.0.23        BOUND      3099       PE2.102              default    0x0

0010.9400.c02c  10.0.0.24        BOUND      3099       PE2.102              default    0x0

0010.9400.c02d  10.0.0.25        BOUND      3099       PE2.102              default    0x0

0010.9400.c02e  10.0.0.26        BOUND      3099       PE2.102              default    0x0

0010.9400.c02f  10.0.0.27        BOUND      3099       PE2.102              default    0x0

0010.9400.c030  10.0.0.28        BOUND      3099       PE2.102              default    0x0

0010.9400.c031  10.0.0.29        BOUND      3099       PE2.102              default    0x0
```

```
0010.9400.c032  10.0.0.30        BOUND      3099       PE2.102              default    0x0

0010.9400.c033  10.0.0.11        BOUND      3099       PE2.102              default    0x0

0010.9400.c020  10.0.0.45        BOUND      3201       PE2.101              default    0x0

0010.9400.c021  10.0.0.46        BOUND      3201       PE2.101              default    0x0

0010.9400.c022  10.0.0.47        BOUND      3201       PE2.101              default    0x0

0010.9400.c023  10.0.0.48        BOUND      3201       PE2.101              default    0x0

0010.9400.c024  10.0.0.49        BOUND      3201       PE2.101              default    0x0

0010.9400.c025  10.0.0.50        BOUND      3201       PE2.101              default    0x0

0010.9400.c026  10.0.0.51        BOUND      3201       PE2.101              default    0x0

0010.9400.c027  10.0.0.52        BOUND      3201       PE2.101              default    0x0

0010.9400.c028  10.0.0.53        BOUND      3201       PE2.101              default    0x0

0010.9400.c029  10.0.0.54        BOUND      3201       PE2.101              default    0x0
```

Configure DHCP Proxy

Perform these tasks to configure DHCP proxy on PWHE interface.

```
Router# configure
Router(config)# dhcp ipv4
Router(config-dhcpv4)# profile prox1 proxy
Router(config-dhcpv4-proxy-profile)# helper-address vrf default 10.0.0.1 giaddr 0.0.0.0
Router(config-dhcpv4-proxy-profile)# relay information check
Router(config-dhcpv4-proxy-profile)# relay information option
Router(config-dhcpv4-proxy-profile)# relay information option allow-untrusted
Router(config-dhcpv4-proxy-profile)# exit
Router(config-dhcpv4)#interface PW-Ether2.201 proxy profile prox
Router(config-dhcpv4)#interface PW-Ether2.202 proxy profile prox
Router(config-dhcpv4)#commit
```

Running Configuration

This section shows DHCP proxy running configuration.

```
configure
 dhcp ipv4
  profile prox1 proxy
   helper-address vrf default 10.0.0.1 giaddr 0.0.0.0
   relay information check
   relay information option
   relay information option allow-untrusted
 !
 !

 interface PW-Ether2.101 proxy profile prox
 interface PW-Ether2.102 proxy profile prox
```

Verification

Verify DHCP proxy configuration.

```
Router#show dhcp ipv4 proxy binding summary
Wed Jun  5 08:07:22.537 IST

Total number of clients: 3724

     STATE                 |     COUNT     |
-------------------------------------
  INIT                     |             0  |
  INIT_DPM_WAITING         |             0  |
  SELECTING                |             0  |
  OFFER_SENT               |             0  |
  REQUESTING               |             0  |
  REQUEST_INIT_DPM_WAITING|             0  |
  ACK_DPM_WAITING          |             0  |
  BOUND                    |          3724  |
  RENEWING                 |             0  |
  INFORMING                |             0  |
  REAUTHORIZE              |             0  |
  DISCONNECT_DPM_WAIT      |             0  |
  ADDR_CHANGE_DPM_WAIT     |             0  |
  DELETING                 |             0  |
  DISCONNECTED             |             0  |
  RESTARTING               |             0  |
```

Configure DHCP Relay

Perform these tasks to configure DHCP relay on PWHE interface.

```
Router# configure
Router(config)# dhcp ipv4
Router(config-dhcpv4)# profile relay1 relay
Router(config-dhcpv4-proxy-profile)# helper-address vrf default 10.0.0.1 giaddr 0.0.0.0
Router(config-dhcpv4-proxy-profile)# relay information option vpn
Router(config-dhcpv4-proxy-profile)# relay information check
Router(config-dhcpv4-proxy-profile)# relay information option
Router(config-dhcpv4-relay-profile)# relay information option vpn-mode rfc
Router(config-dhcpv4-proxy-profile)# relay information option allow-untrusted
Router(config-dhcpv4-proxy-profile)# exit
Router(config-dhcpv4)#interface PW-Ether2.201 proxy profile prox
Router(config-dhcpv4)#interface PW-Ether2.202 proxy profile prox
Router(config-dhcpv4)#commit
```

Running Configuration

This section shows DHCP relay running configuration.

```
configure
 dhcp ipv4
  profile relay1 relay
   helper-address vrf default 10.0.0.1 giaddr 0.0.0.0
   relay information option vpn
   relay information check
   relay information option
   relay information option vpn-mode rfc
   relay information option allow-untrusted
 !
 !

 interface PW-Ether2.101 relay profile relay1
 interface PW-Ether2.102 relay profile relay1
```

Verification

Verify DHCP Relay configuration.

```
Router# show dhcp ivp4 relay profile name relay1
Profile: relay1 relay
Helper Addresses:
10.0.0.1, vrf default, giaddr 0.0.0.0
Remote-Id Format : [ascii | hex]
Remote-Id value : cisco
Information Option: Enabled
Information Option Allow Untrusted: Enabled
Information Option VPN: Enabled
Information Option VPN Mode: RFC
Information Option Policy: Replace
```

Related Topics

- DHCP on PWHE Interfaces, on page 49

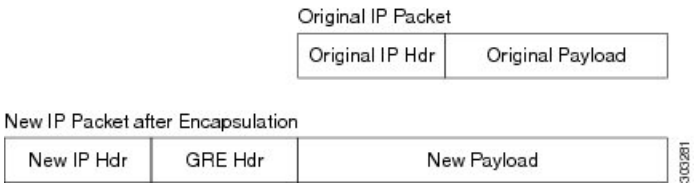
Associated Commands

- show l2vpn xconnect
- show dhcp ipv4 server binding
- show dhcp ipv4 proxy binding summary
- show dhcp ipv4 relay profile name

L2VPN over GRE

To transport an IP packet over a generic routing encapsulation (GRE) tunnel, the system first encapsulates the original IP packet with a GRE header. The encapsulated GRE packet is encapsulated once again by an outer transport header that is used to forward the packet to it's destination. The following figure captures how GRE encapsulation over an IP transport network takes place.

Figure 15: GRE Encapsulation



Note In the new IP packet, new payload is similar to the original IP packet. Additionally, the new IP header (New IP Hdr) is similar to the tunnel IP header which in turn is similar to the transport header.

When a GRE tunnel endpoint decapsulates a GRE packet, it further forwards the packet based on the payload type. For example, if the payload is a labeled packet then the packet is forwarded based on the virtual circuit (VC) label or the VPN label for L2VPN and L3VPN respectively.

L2VPN over GRE Restrictions

Some of the restrictions that you must consider while configuring L2VPN over GRE:

- GRE over BVI is not supported.
- For VPLS flow-based load balancing scenario, the GRE tunnel is pinned down to outgoing path based on tunnel source or destination cyclic redundancy check (CRC). Unicast and flood traffic always takes the same physical path for a given GRE tunnel.
- Ingress attachment circuit must be an ASR 9000 Enhanced Ethernet Line Card for L2VPN over GRE. Additionally, GRE tunnel destination should be reachable only on an ASR 9000 Enhanced Ethernet Line Card.
- The L2VPN over GRE feature is not supported on the ASR 9000 Ethernet Line Card or Cisco ASR 9000 Series SPA Interface Processor-700 line cards as the ingress attachment circuit and GRE destination is reachable over GRE.
- Pseudowire over TE over GRE scenario is not supported.
- Preferred Path Limitations:
  - When you configure GRE as a preferred path, egress features are not supported under the GRE tunnel (Egress ACL).
  - VCCV ping or traceroute are not supported for preferred path.
  - Preferred path is supported only for pseudowires configured in a provider egde (PE) to PE topology.

GRE Deployment Scenarios

In an L2VPN network, you can deploy GRE in the following scenarios:

- Configuring GRE tunnel between provider edge (PE) to PE routers
- Configuring GRE tunnel between P to P routers
- Configuring GRE tunnel between P to PE routers

The following diagrams depict the various scenarios:

Figure 16: GRE tunnel configured between PE to PE routers

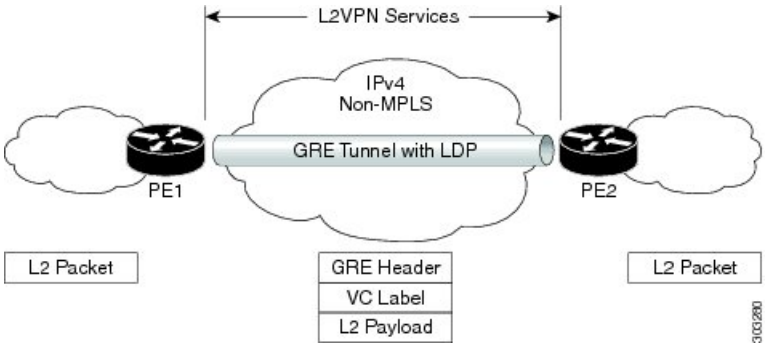


Figure 17: GRE tunnel configured between P to P routers

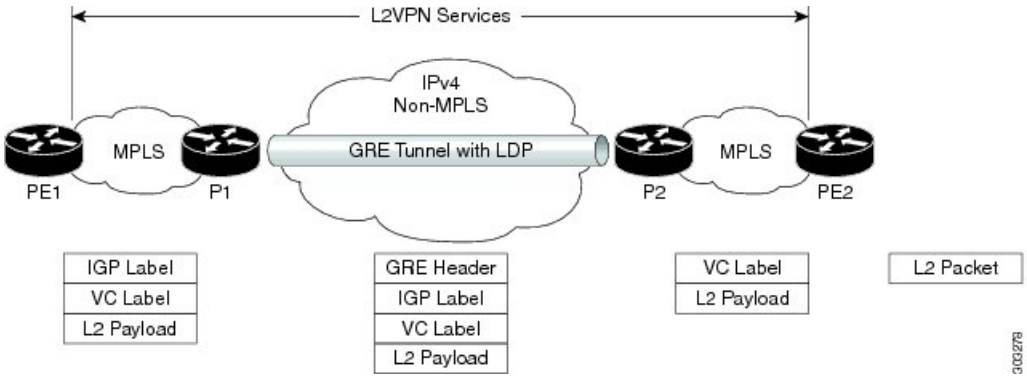
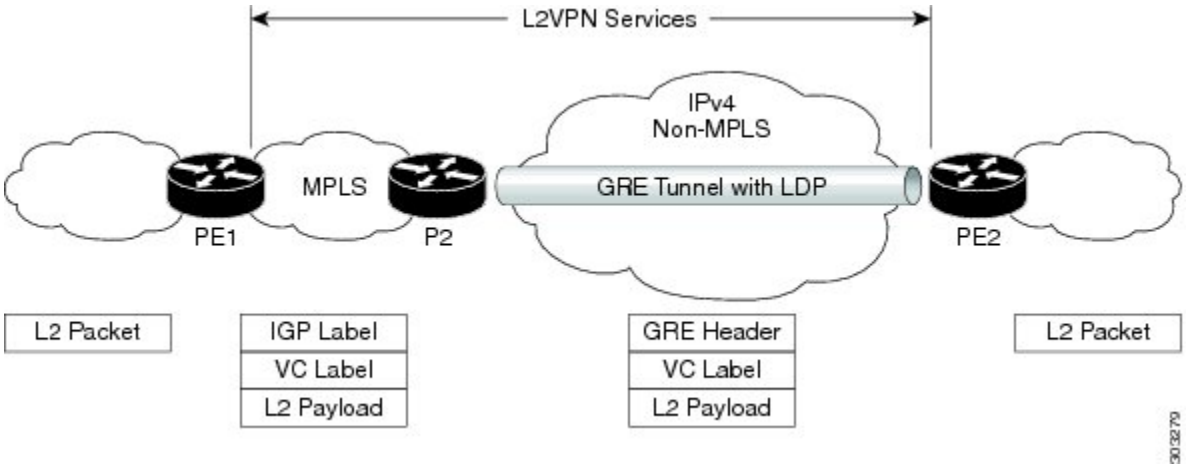


Figure 18: GRE tunnel configured between P to PE routers



Note These deployment scenarios are applicable to VPWS and VPLS.

GRE Tunnel as Preferred Path

Preferred tunnel path feature allows you to map pseudowires to specific GRE tunnels. Attachment circuits are cross-connected to GRE tunnel interfaces instead of remote PE router IP addresses (reachable using IGP or LDP). Using preferred tunnel path, it is always assumed that the GRE tunnel that transports the L2 traffic runs between the two PE routers (that is, its head starts at the imposition PE router and terminates on the disposition PE router).

How to Implement Multipoint Layer 2 Services

This section describes the tasks that are required to implement Multipoint Layer 2 Services:

Configuring a Bridge Domain

These topics describe how to configure a bridge domain:

Creating a Bridge Domain

Perform this task to create a bridge domain .

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group that can contain bridge domains, and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring a Pseudowire

Perform this task to configure a pseudowire under a bridge domain.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge group name*
4. **bridge-domain** *bridge-domain name*
5. **vfi** { *vfi-name* }
6. **exit**
7. **neighbor** { *A.B.C.D* } { **pw-id** *value* }
8. **dhcp ipv4 snoop profile** *{ dhcp_snoop_profile_name }*
9. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge group name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **vfi** { *vfi-name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# vfi v1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)#
```

Configures the virtual forwarding interface (VFI) parameters and enters L2VPN bridge group bridge domain VFI configuration mode.

- Use the *vfi-name* argument to configure the name of the specified virtual forwarding interface.

Step 6 **exit**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Exits the current configuration mode.

Step 7 **neighbor** { *A.B.C.D* } { **pw-id** *value* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# neighbor 10.1.1.2 pw-id 1000
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw)#
```

Adds an access pseudowire port to a bridge domain or a pseudowire to a bridge virtual forwarding interface (VFI).

- Use the *A.B.C.D* argument to specify the IP address of the cross-connect peer.
- Use the **pw-id** keyword to configure the pseudowire ID and ID value. The range is 1 to 4294967295.

Step 8 **dhcp ipv4 snoop profile** *{ dhcp_snoop_profile_name }*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw)#dhcp ipv4 snoop profile profile1
```

Enables DHCP snooping on the bridge, and attaches a DHCP snooping profile.

Step 9 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Associating Members with a Bridge Domain

After a bridge domain is created, perform this task to assign interfaces to the bridge domain. These types of bridge ports are associated with a bridge domain:

- Ethernet and VLAN
- VFI

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge group name*
4. **bridge-domain** *bridge-domain name*
5. **interface** *type interface-path-id*
6. *(Optional)* **static-mac-address** { *MAC-address* }
7. **routed interface** *BVI-id*
8. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge group name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **interface** *type interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# interface GigabitEthernet 0/4/0/0
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#
```

Enters interface configuration mode and adds an interface to a bridge domain that allows packets to be forwarded and received from other interfaces that are part of the same bridge domain.

Step 6 *(Optional)* **static-mac-address** { *MAC-address* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# static-mac-address 1.1.1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Configures the static MAC address to associate a remote MAC address with a pseudowire or any other bridge interface.

Step 7 **routed interface** *BVI-id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# routed interface BVI100
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#
```

Perform this step if you need the VPLS pseudowire traffic routed over an Integrated Routing and Bridging (IRB). This command enters bridge-group virtual interface configuration mode and adds a bridge-group virtual interface (BVI) to the bridge domain that allows packets to be forwarded and received from other interfaces that are part of the same bridge domain. This step is essential to bring the BVI's status up.

Step 8 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring Bridge Domain Parameters

To configure bridge domain parameters, associate these parameters with a bridge domain:

- Maximum transmission unit (MTU)—Specifies that all members of a bridge domain have the same MTU. The bridge domain member with a different MTU size is not used by the bridge domain even though it is still associated with a bridge domain.
- Flooding—Flooding is enabled always.
- Dynamic ARP Inspection (DAI)—Ensures only valid ARP requests and responses are relayed.
- IP SourceGuard (IPSG)—Enables source IP address filtering on a Layer 2 port.

Note To verify if the DAI and IPSG features are working correctly, look up the packets dropped statistics for DAI and IPSG violation. The packet drops statistics can be viewed in the output of the **show l2vpn bridge-domain** *bd-name* <> **detail** command.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **flooding disable**
6. **mtu** *bytes*
7. **dynamic-arp-inspection** { **address-validation** | **disable** | **logging** }
8. **ip-source-guard logging**
9. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters the l2vpn configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters l2vpn bridge group bridge domain configuration mode.

Step 5 **flooding disable**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# flooding disable
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Disables flooding.

Step 6 **mtu** *bytes*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# mtu 1000
```

Adjusts the maximum packet size or maximum transmission unit (MTU) size for the bridge domain.

- Use the *bytes* argument to specify the MTU size, in bytes. The range is from 64 to 65535.

Step 7 **dynamic-arp-inspection** { **address-validation** | **disable** | **logging** }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# dynamic-arp-inspection
```

Enters the dynamic ARP inspection configuration submode. Ensures only valid ARP requests and responses are relayed.

Note You can configure dynamic ARP inspection under the bridge domain or the bridge port.

Step 8 **ip-source-guard logging**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# ip-source-guard logging
```

Enters the IP source guard configuration submode and enables source IP address filtering on a Layer 2 port.

You can enable IP source guard under the bridge domain or the bridge port. By default, bridge ports under a bridge inherit the IP source guard configuration from the parent bridge.

By default, IP source guard is disabled on the bridges.

Step 9 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Disabling a Bridge Domain

Perform this task to disable a bridge domain. When a bridge domain is disabled, all VFIs that are associated with the bridge domain are disabled. You are still able to attach or detach members to the bridge domain and the VFIs that are associated with the bridge domain.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge group name*
4. **bridge-domain** *bridge-domain name*
5. **shutdown**
6. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge group name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters l2vpn bridge group bridge domain configuration mode.

Step 5 **shutdown**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# shutdown
```

Shuts down a bridge domain to bring the bridge and all attachment circuits and pseudowires under it to admin down state.

Step 6 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Blocking Unknown Unicast Flooding

Perform this task to disable flooding of unknown unicast traffic at the bridge domain level.

You can disable flooding of unknown unicast traffic at the bridge domain, bridge port or access pseudowire levels. By default, unknown unicast traffic is flooded to all ports in the bridge domain.

Note If you disable flooding of unknown unicast traffic on the bridge domain, all ports within the bridge domain inherit this configuration. You can configure the bridge ports to override the bridge domain configuration.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **flooding unknown-unicast disable**

6. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters l2vpn bridge group bridge domain configuration mode.

Step 5 **flooding unknown-unicast disable**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
flooding unknown-unicast disable
```

Disables flooding of unknown unicast traffic at the bridge domain level.

Step 6 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Changing the Flood Optimization Mode

Perform this task to change the flood optimization mode under the bridge domain:

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **flood mode convergence-optimized**
6. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters l2vpn bridge group bridge domain configuration mode.

Step 5 **flood mode convergence-optimized**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# flood mode convergence-optimized
```

Changes the default flood optimization mode from Bandwidth Optimization Mode to Convergence Mode.

When you configure **flood mode convergence-optimized**, you must remove and reconfigure the bridge domain when you add, modify, or remove the pseudowire configuration of a specific bridge domain.

Step 6 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring Layer 2 Security

These topics describe how to configure Layer 2 security:

Enabling Layer 2 Security

Perform this task to enable Layer 2 port security on a bridge.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge domain** *bridge-domain-name*
5. **security**
6. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Assigns each network interface to a bridge group and enters L2VPN bridge group configuration mode.

Step 4 **bridge domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **security**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# security
```

Enables Layer 2 port security on a bridge.

Step 6 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Attaching a Dynamic Host Configuration Protocol Profile

Perform this task to enable DHCP snooping on a bridge and to attach a DHCP snooping profile to a bridge.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **dhcp ipv4 snoop** { **profile** *profile-name* }
6. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Assigns each network interface to a bridge group and enters L2VPN bridge group configuration mode.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **dhcp ipv4 snoop** { **profile** *profile-name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# dhcp ipv4 snoop profile attach
```

Enables DHCP snooping on a bridge and attaches DHCP snooping profile to the bridge.

- Use the profile keyword to attach a DHCP profile. The profile-name argument is the profile name for DHCPv4 snooping.

Step 6 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.

- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring a Layer 2 Virtual Forwarding Instance

These topics describe how to configure a Layer 2 virtual forwarding instance (VFI):

Creating the Virtual Forwarding Instance

Perform this task to create a Layer 2 Virtual Forwarding Instance (VFI) on all provider edge devices under the bridge domain.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge group name*
4. **bridge-domain** *bridge-domain name*
5. **vfi** {*vfi-name*}
6. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge group name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **vfi** {*vfi-name*}

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# vfi v1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)#
```

Configures virtual forwarding interface (VFI) parameters and enters L2VPN bridge group bridge domain VFI configuration mode.

Step 6 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Associating Pseudowires with the Virtual Forwarding Instance

After a VFI is created, perform this task to associate one or more pseudowires with the VFI.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **vfi** { *vfi name* }
6. **neighbor** { *A.B.C.D* } { **pw-id** *value* }
7. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **vfi** { *vfi name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# vfi v1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)#
```

Configures virtual forwarding interface (VFI) parameters and enters L2VPN bridge group bridge domain VFI configuration mode.

Step 6 **neighbor** { *A.B.C.D* } { **pw-id** *value* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# neighbor 10.1.1.2 pw-id 1000
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)#
```

Adds a pseudowire port to a bridge domain or a pseudowire to a bridge virtual forwarding interface (VFI).

- Use the *A.B.C.D* argument to specify the IP address of the cross-connect peer.
- Use the **pw-id** keyword to configure the pseudowire ID and ID value. The range is 1 to 4294967295.

Step 7 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.

- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Associating a Virtual Forwarding Instance to a Bridge Domain

Perform this task to associate a VFI to be a member of a bridge domain.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge group name*
4. **bridge-domain** *bridge-domain name*
5. **vfi** { *vfi name* }
6. **neighbor** { *A.B.C.D* } { **pw-id** *value* }
7. **static-mac-address** { *MAC-address* }
8. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters the L2VPN configuration mode.

Step 3 **bridge group** *bridge group name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
```

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **vfi** { *vfi name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# vfi v1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)#
```

Configures virtual forwarding interface (VFI) parameters and enters L2VPN bridge group bridge domain VFI configuration mode.

Step 6 **neighbor** { *A.B.C.D* } { **pw-id** *value* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# neighbor 10.1.1.2 pw-id 1000
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)#
```

Adds a pseudowire port to a bridge domain or a pseudowire to a bridge virtual forwarding interface (VFI).

- Use the *A.B.C.D* argument to specify the IP address of the cross-connect peer.
- Use the **pw-id** keyword to configure the pseudowire ID and ID value. The range is 1 to 4294967295.

Step 7 **static-mac-address** { *MAC-address* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)# static-mac-address 1.1.1
```

Configures the static MAC address to associate a remote MAC address with a pseudowire or any other bridge interface.

Step 8 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Attaching Pseudowire Classes to Pseudowires

Perform this task to attach a pseudowire class to a pseudowire.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge group name*

4. **bridge-domain** *bridge-domain name*
5. **vfi** { *vfi-name* }
6. **neighbor** { *A.B.C.D* } { **pw-id** *value* }
7. **pw-class** { *class-name* }
8. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters the L2VPN configuration mode.

Step 3 **bridge group** *bridge group name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **vfi** { *vfi-name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# vfi v1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)#
```

Configures virtual forwarding interface (VFI) parameters and enters L2VPN bridge group bridge domain VFI configuration mode.

Step 6 **neighbor** { *A.B.C.D* } { **pw-id** *value* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# neighbor 10.1.1.2 pw-id 1000
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)#
```

Adds a pseudowire port to a bridge domain or a pseudowire to a bridge virtual forwarding interface (VFI).

- Use the *A.B.C.D* argument to specify the IP address of the cross-connect peer.
- Use the **pw-id** keyword to configure the pseudowire ID and ID value. The range is 1 to 4294967295.

Step 7 **pw-class** { *class-name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)# pw-class canada
```

Configures the pseudowire class template name to use for the pseudowire.

Step 8 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring Pseudowires Using Static Labels

Perform this task to configure the Any Transport over Multiprotocol (AToM) pseudowires by using the static labels. A pseudowire becomes a static AToM pseudowire by setting the MPLS static labels to local and remote.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **vfi** { *vfi-name* }
6. **neighbor** { *A.B.C.D* } { **pw-id** *value* }
7. **mpls static label** { **local** *value* } { **remote** *value* }
8. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters the L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **vfi** { *vfi-name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# vfi v1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)#
```

Configures virtual forwarding interface (VFI) parameters and enters L2VPN bridge group bridge domain VFI configuration mode.

Step 6 **neighbor** { *A.B.C.D* } { **pw-id** *value* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# neighbor 10.1.1.2 pw-id 1000
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)#
```

Adds a pseudowire port to a bridge domain or a pseudowire to a bridge virtual forwarding interface (VFI).

- Use the *A.B.C.D* argument to specify the IP address of the cross-connect peer.
- Use the **pw-id** keyword to configure the pseudowire ID and ID value. The range is 1 to 4294967295.

Step 7 **mpls static label** { **local** *value* } { **remote** *value* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)# mpls static label local 800 remote 500
```

Configures the MPLS static labels and the static labels for the pseudowire configuration. You can set the local and remote pseudowire labels.

Step 8 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Disabling a Virtual Forwarding Instance

Perform this task to disable a VFI. When a VFI is disabled, all the previously established pseudowires that are associated with the VFI are disconnected. LDP advertisements are sent to withdraw the MAC addresses that are associated with the VFI. However, you can still attach or detach attachment circuits with a VFI after a shutdown.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge group name*
4. **bridge-domain** *bridge-domain name*
5. **vfi** { *vfi-name* }
6. **shutdown**
7. Use the **commit** or **end** command.
8. **show l2vpn bridge-domain** [**detail**]

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters the L2VPN configuration mode.

Step 3 **bridge group** *bridge group name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **vfi** { *vfi-name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# vfi v1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)#
```

Configures virtual forwarding interface (VFI) parameters and enters L2VPN bridge group bridge domain VFI configuration mode.

Step 6 **shutdown**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# shutdown
```

Disables the virtual forwarding interface (VFI).

Step 7 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Step 8 **show l2vpn bridge-domain** [**detail**]

Example:

```
RP/0/RSP0/CPU0:router# show l2vpn bridge-domain detail
```

Displays the state of the VFI. For example, if you shut down the VFI, the VFI is shown as shut down under the bridge domain.

Configuring the MAC Address-related Parameters

These topics describe how to configure the MAC address-related parameters:

The MAC table attributes are set for the bridge domains.

Configuring the MAC Address Source-based Learning

Perform this task to configure the MAC address source-based learning.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge group name*
4. **bridge-domain** *bridge-domainname*
5. **mac**
6. **learning disable**
7. Use the **commit** or **end** command.
8. **show l2vpn bridge-domain** [**detail**]

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters the L2VPN configuration mode.

Step 3 **bridge group** *bridge group name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domainname*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **mac**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# mac
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)#
```

Enters L2VPN bridge group bridge domain MAC configuration mode.

Step 6 **learning disable**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)# learning disable
```

Disables MAC learning at the bridge domain level.

Step 7 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Step 8 **show l2vpn bridge-domain** [**detail**]

Example:

```
RP/0/RSP0/CPU0:router# show l2vpn bridge-domain detail
```

Displays the details that the MAC address source-based learning is disabled on the bridge.

Enabling the MAC Address Withdrawal

Perform this task to enable the MAC address withdrawal for a specified bridge domain.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **mac**

6. **withdrawal**
7. Use the **commit** or **end** command.
8. **show l2vpn bridge-domain [detail]**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN l2vpn bridge group bridge domain configuration mode.

Step 5 **mac**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# mac
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)#
```

Enters L2VPN l2vpn bridge group bridge domain MAC configuration mode.

Step 6 **withdrawal**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)# withdrawal
```

Enables the MAC address withdrawal for a specified bridge domain.

Step 7 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Step 8 **show l2vpn bridge-domain [detail]**

Example:

```
RP/0/RSP0/CPU0:router# show l2vpn bridge-domain detail
```

Displays detailed sample output to specify that the MAC address withdrawal is enabled. In addition, the sample output displays the number of MAC withdrawal messages that are sent over or received from the pseudowire.

Configuring the MAC Address Limit

Perform this task to configure the parameters for the MAC address limit.

Note MAC Address Limit action is supported only on the ACs and not on the core pseudowires.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge group name*
4. **bridge-domain** *bridge-domain name*
5. *(Optional)* **interface** *type interface_id*
6. **mac**
7. **limit**
8. **maximum** { *value* }
9. **action** { **flood** | **no-flood** | **shutdown** }
10. **notification** { **both** | **none** | **trap** }
11. **mac limit threshold** *80*
12. Use the **commit** or **end** command.
13. **show l2vpn bridge-domain** [**detail**]

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters the L2VPN configuration mode.

Step 3 **bridge group** *bridge group name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 *(Optional)* **interface** *type interface_id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# interface gigabitEthernet 0/2/0/1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#
```

Enters the interface configuration mode of the specified interface and adds this interface as the bridge domain member interface.

Note Run this step if you want to configure the MAC address limit only for a specific interface. The further steps show the router prompt displayed when you have skipped this step to configure the MAC address limit at the bridge domain level.

Step 6 **mac**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# mac
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)#
```

Enters L2VPN bridge group bridge domain MAC configuration mode.

Step 7 **limit**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)# limit
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac-limit)#
```

Sets the MAC address limit for action, maximum, and notification and enters L2VPN bridge group bridge domain MAC limit configuration mode.

Step 8 **maximum** { *value* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac-limit)# maximum 5000
```

Configures the specified action when the number of MAC addresses learned on a bridge is reached.

Step 9 **action** { **flood** | **no-flood** | **shutdown** }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac-limit)# action flood
```

Configures the bridge behavior when the number of learned MAC addresses exceed the MAC limit configured.

Step 10 **notification** { **both** | **none** | **trap** }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac-limit)# notification both
```

Specifies the type of notification that is sent when the number of learned MAC addresses exceeds the configured limit.

Step 11 **mac limit threshold** *80*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# mac limit threshold 80
```

Configures the MAC limit threshold. The default is 75% of MAC address limit configured in step 8.

Step 12 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.

- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Step 13 **show l2vpn bridge-domain** [**detail**]

Example:

```
RP/0/RSP0/CPU0:router# show l2vpn bridge-domain detail
```

Displays the details about the MAC address limit.

Configuring the MAC Address Aging

Perform this task to configure the parameters for MAC address aging.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **mac**
6. **aging**
7. **time** { *seconds* }
8. Use the **commit** or **end** command.
9. **show l2vpn bridge-domain** [**detail**]

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters the L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **mac**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# mac
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)#
```

Enters L2VPN bridge group bridge domain MAC configuration mode.

Step 6 **aging**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)# aging
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac-aging)#
```

Enters the MAC aging configuration submode to set the aging parameters such as time and type.

The maximum MAC age for ASR 9000 Ethernet and ASR 9000 Enhanced Ethernet line cards is two hours.

Step 7 **time** { *seconds* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac-aging)# time 300
```

Configures the maximum aging time.

- Use the *seconds* argument to specify the maximum age of the MAC address table entry. The range is from 300 to 30000 seconds. Aging time is counted from the last time that the switch saw the MAC address. The default value is 300 seconds.

Step 8 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Step 9 **show l2vpn bridge-domain** [**detail**]

Example:

```
RP/0/RSP0/CPU0:router# show l2vpn bridge-domain detail
```

Displays the details about the aging fields.

Disabling MAC Flush at the Bridge Port Level

Perform this task to disable the MAC flush at the bridge domain level.

You can disable the MAC flush at the bridge domain or bridge port level. By default, the MACs learned on a specific port are immediately flushed, when that port becomes nonfunctional.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **mac**
6. **port-down flush disable**
7. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters l2vpn bridge group bridge domain configuration mode.

Step 5 **mac**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# mac
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)#
```

Enters l2vpn bridge group bridge domain MAC configuration mode.

Step 6 **port-down flush disable**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)#
port-down flush disable
```

Disables MAC flush when the bridge port becomes nonfunctional.

Step 7 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring MAC Address Security

Perform this task to configure MAC address security.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group***bridge-group-name*
4. **bridge-domain***bridge-domain-name*
5. **neighbor** { *A.B.C.D* } { **pw-id** *value* }
6. **mac**
7. **secure [action | disable | logging]**
8. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Enters L2VPN configuration mode.

Step 3 **bridge group***bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain***bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters L2VPN l2vpn bridge group bridge domain configuration mode.

Step 5 **neighbor** { *A.B.C.D* } { **pw-id** *value* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# neighbor 10.1.1.2 pw-id 1000
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw)#
```

Adds an access pseudowire port to a bridge domain, or a pseudowire to a bridge virtual forwarding interface (VFI).

- Use the A.B.C.D argument to specify the IP address of the cross-connect peer.
- Use the pw-id keyword to configure the pseudowire ID and ID value. The range is 1 to 4294967295.

Step 6 **mac**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw)# mac
```

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw-mac)#
```

Enters L2VPN l2vpn bridge group bridge domain MAC configuration mode.

Step 7 **secure [action | disable | logging]**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw-mac)#
secure
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw-mac-
secure)#
```

Enters MAC secure configuration mode.

By default, bridge ports (interfaces and access pseudowires) under a bridge inherit the security configuration from the parent bridge.

Note Once a bridge port goes down, a **clear** command must be issued to bring the bridge port up.

Step 8 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring an Attachment Circuit to the AC Split Horizon Group

These steps show how to add an interface to the split horizon group for attachment circuits (ACs) under a bridge domain.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **interface** *type instance*
6. **split-horizon group**
7. **commit**
8. **end**
9. **show l2vpn bridge-domain detail**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group metroA
```

Enters configuration mode for the named bridge group.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain east
```

Enters configuration mode for the named bridge domain.

Step 5 **interface** *type instance*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# interface GigabitEthernet0/1/0/6
```

Enters configuration mode for the named interface.

Step 6 **split-horizon group**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# split-horizon group
```

Enters configuration mode for the named interface.

Step 7 **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# commit
```

Saves configuration changes

Step 8 **end**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# end
```

Returns to EXEC mode.

Step 9 **show l2vpn bridge-domain detail**

Example:

```
RP/0/RSP0/CPU0:router show l2vpn bridge-domain detail
```

Displays information about bridges, including whether each AC is in the AC split horizon group or not.

Adding an Access Pseudowire to the AC Split Horizon Group

These steps show how to add an access pseudowire as a member to the split horizon group for attachment circuits (ACs) under a bridge domain.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **neighbor** *A.B.C.D* **pw-id** *pseudowire-id*
6. **split-horizon group**
7. **commit**
8. **end**
9. **show l2vpn bridge-domain detail**

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group metroA
```

Enters configuration mode for the named bridge group.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain east
```

Enters configuration mode for the named bridge domain.

Step 5 **neighbor** *A.B.C.D* **pw-id** *pseudowire-id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# neighbor 10.2.2.2 pw-id 2000
```

Configures the pseudowire segment.

Step 6 **split-horizon group**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# split-horizon group
```

Adds this interface to the split horizon group for ACs. Only one split horizon group for ACs

Note Only one split horizon group for ACs and access pseudowires per bridge domain is supported

.

Step 7 **commit**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw) commit
```

Saves configuration changes

Step 8 **end**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# end
```

Returns to EXEC mode.

Step 9 **show l2vpn bridge-domain detail**

Example:

```
RP/0/RSP0/CPU0:router # show l2vpn bridge-domain detail
```

Displays information about bridges, including whether each AC is in the AC split horizon group or not.

Configuring VPLS with BGP Autodiscovery and Signaling

Perform this task to configure BGP-based autodiscovery and signaling.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge group name*
4. **bridge-domain** *bridge-domain name*
5. **vfi** { *vfi-name* }
6. **vpn-id** *vpn-id*
7. **autodiscovery bgp**
8. **rd** { *as-number:nn* | *ip-address:nn* | **auto** }
9. **route-target** { *as-number:nn* | *ip-address:nn* | **export** | **import** }
10. **route-target import** { *as-number:nn* | *ip-address:nn* }
11. **route-target export** { *as-number:nn* | *ip-address:nn* }
12. **signaling-protocol bgp**
13. **ve-id** { *number*}
14. **ve-range** { *number* }
15. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge group name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group metroA
```

Enters configuration mode for the named bridge group.

Step 4 **bridge-domain** *bridge-domain name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain east
```

Enters configuration mode for the named bridge domain.

Step 5 **vfi** { *vfi-name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# vfi vfi-east
```

Enters virtual forwarding instance (VFI) configuration mode.

Step 6 **vpn-id** *vpn-id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# vpn-id 100
```

Specifies the identifier for the VPLS service. The VPN ID has to be globally unique within a PE router. i.e., the same VPN ID cannot exist in multiple VFIs on the same PE router. In addition, a VFI can have only one VPN ID.

Step 7 **autodiscovery bgp**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# autodiscovery bgp
```

Enters BGP autodiscovery configuration mode where all BGP autodiscovery parameters are configured.

This command is not provisioned to BGP until at least the VPN ID and the signaling protocol is configured.

Step 8 **rd** { *as-number:nn* | *ip-address:nn* | **auto** }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad)# rd auto
```

Specifies the route distinguisher (RD) under the VFI.

The RD is used in the BGP NLRI to identify VFI. Only one RD can be configured per VFI, and except for **rd auto** the same RD cannot be configured in multiple VFIs on the same PE.

When **rd auto** is configured, the RD value is as follows: {BGP Router ID}:{16 bits auto-generated unique index}.

Step 9 **route-target** { *as-number:nn* | *ip-address:nn* | **export** | **import** }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad)# route-target 500:99
```

Specifies the route target (RT) for the VFI.

At least one import and one export route targets (or just one route target with both roles) need to be configured in each PE in order to establish BGP autodiscovery between PEs.

If no export or import keyword is specified, it means that the RT is both import and export. A VFI can have multiple export or import RTs. However, the same RT is not allowed in multiple VFIs in the same PE.

Step 10 **route-target import** { *as-number:nn* | *ip-address:nn* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad)# route-target import 200:20
```

Specifies the import route target for the VFI.

Import route target is what the PE compares with the RT in the received NLRI: the RT in the received NLRI must match the import RT to determine that the RTs belong to the same VPLS service.

Step 11 **route-target export** { *as-number:nn* | *ip-address:nn* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad)# route-target export 100:10
```

Specifies the export route target for the VFI.

Export route target is the RT that is going to be in the NLRI advertised to other PEs.

Step 12 **signaling-protocol bgp**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad)# signaling-protocol bgp
```

Enables BGP signaling, and enters the BGP signaling configuration submode where BGP signaling parameters are configured.

This command is not provisioned to BGP until VE ID and VE ID range is configured.

Step 13 **ve-id** { *number*}

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad-sig)# ve-id 10
```

Specifies the local PE identifier for the VFI for VPLS configuration.

The VE ID identifies a VFI within a VPLS service. This means that VFIs in the same VPLS service cannot share the same VE ID. The scope of the VE ID is only within a bridge domain. Therefore, VFIs in different bridge domains within a PE can use the same VE ID.

Step 14 **ve-range** { *number* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad-sig)# ve-range 40
```

Overrides the minimum size of VPLS edge (VE) blocks.

The default minimum size is 10. Any configured VE range must be higher than 10.

Step 15 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.

- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring VPLS with BGP Autodiscovery and LDP Signaling

Perform this task to configure BGP-based Autodiscovery and signaling:

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **router-id** *ip-address*
4. **bridge group** *bridge-group-name*
5. **bridge-domain** *bridge-domain-name*
6. **transport-mode vlan passthrough**
7. **vfi** {*vfi-name*}
8. **autodiscovery bgp**
9. **vpn-id** *vpn-id*
10. **rd** {*as-number:nn* | *ip-address:nn* | **auto**}
11. **route-target** {*as-number:nn* | *ip-address:nn* | **export** | **import** }
12. **route-target import** {*as-number:nn* | *ip-address:nn*}
13. **route-target export** {*as-number:nn* | *ip-address:nn*}
14. **signaling-protocol ldp**
15. **vpls-id** {*as-number:nn* | *ip-address:nn*}
16. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **router-id** *ip-address*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# router-id 10.0.0.1
```

Specifies a unique Layer 2 (L2) router ID for the provider edge (PE) router.

The router ID must be configured for LDP signaling, and is used as the L2 router ID in the BGP NLRI, SAII (local L2 Router ID) and TAII (remote L2 Router ID). Any arbitrary value in the IPv4 address format is acceptable.

Note Each PE must have a unique L2 router ID. This CLI is optional, as a PE automatically generates a L2 router ID using the LDP router ID.

Step 4 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group metroA
```

Enters configuration mode for the named bridge group.

Step 5 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain east
```

Enters configuration mode for the named bridge domain.

Step 6 **transport-mode vlan passthrough**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# transport-mode vlan passthrough
```

Enables VC type 4 for BGP autodiscovery.

Step 7 **vfi** {*vfi-name*}

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# vfi vfi-east
```

Enters virtual forwarding instance (VFI) configuration mode.

Step 8 **autodiscovery bgp**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# autodiscovery bgp
```

Enters BGP autodiscovery configuration mode where all BGP autodiscovery parameters are configured.

This command is not provisioned to BGP until at least the VPN ID and the signaling protocol is configured.

Step 9 **vpn-id** *vpn-id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# vpn-id 100
```

Specifies the identifier for the VPLS service. The VPN ID has to be globally unique within a PE router. i.e., the same VPN ID cannot exist in multiple VFIs on the same PE router. In addition, a VFI can have only one VPN ID.

Step 10 **rd** {*as-number:nn* | *ip-address:nn* | **auto**}

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad)# rd auto
```

Specifies the route distinguisher (RD) under the VFI.

The RD is used in the BGP NLRI to identify VFI. Only one RD can be configured per VFI, and except for **rd auto** the same RD cannot be configured in multiple VFIs on the same PE.

When **rd auto**is configured, the RD value is as follows: {BGP Router ID}:{16 bits auto-generated unique index}.

Step 11 **route-target** {*as-number:nn* | *ip-address:nn* | **export** | **import** }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad)# route-target 500:99
```

Specifies the route target (RT) for the VFI.

At least one import and one export route targets (or just one route target with both roles) need to be configured in each PE in order to establish BGP autodiscovery between PEs.

If no export or import keyword is specified, it means that the RT is both import and export. A VFI can have multiple export or import RTs. However, the same RT is not allowed in multiple VFIs in the same PE.

Step 12 **route-target import** {*as-number:nn* | *ip-address:nn*}

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad)# route-target import 200:20
```

Specifies the import route target for the VFI.

Import route target is what the PE compares with the RT in the received NLRI: the RT in the received NLRI must match the import RT to determine that the RTs belong to the same VPLS service.

Step 13 **route-target export** {*as-number:nn* | *ip-address:nn*}

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad)# route-target export 100:10
```

Specifies the export route target for the VFI.

Export route target is the RT that is going to be in the NLRI advertised to other PEs.

Step 14 **signaling-protocol ldp**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad)# signaling-protocol ldp
```

Enables LDP signaling.

Step 15 **vpls-id** {*as-number:nn* | *ip-address:nn*}

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad-sig)# vpls-id 10:20
```

Specifies VPLS ID which identifies the VPLS domain during signaling.

This command is optional in all PEs that are in the same Autonomous System (share the same ASN) because a default VPLS ID is automatically generated using BGP's ASN and the configured VPN ID (i.e., the default VPLS ID equals ASN:VPN-ID). If an ASN of 4 bytes is used, the lower two bytes of the ASN are used to build the VPLS ID. In case of InterAS, the VPLS ID must be explicitly configured. Only one VPLS ID can be configured per VFI, and the same VPLS ID cannot be used for multiple VFIs.

Step 16 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring Service Path Preference

Perform these tasks to configure Service Path Preference:

Setting a Forward Class in a Route Policy

The following configuration shows how to set a forward-class in a route-policy:

```
route-policy  fwd1
      set forward-class 1
end-policy
!
route-policy fwd2
      set forward-class 2
 end-policy
!
```

Attaching a Route Policy at Table Policy Attach Point

The following configuration shows how to attach a route-policy to a table-policy attach point for VPLS bridge-domain VFI:

```
config
```

```
  l2vpn
    bridge group bg1
     bridge-domain bd1
      vfi v1
       autodiscovery bgp
        table-policy fwd1
!
```

The following configuration shows how to attach a route-policy to a table-policy attach point for EVPN EVI:

```
config
  l2vpn
    bridge group pbb
     bridge-domain core1
      pbb core
       evi 1
!
 bridge group edge
  bridge-domain edge1
   pbb edge i-sid 256 core-bridge core1
!
 evpn
  evi 1
    bgp
     table-policy fwd2
!
```

Associating a TE Tunnel with Forward Class Index

The following configuration shows how to associate a TE tunnel with forward-class index:

```
 config
  interface tunnel-te1
   ipv4 unnumbered Loopback0
   autoroute announce
   destination 10.10.10.10
   forward-class 1
   path-option 10 explicit name PATH1
!
```

Enabling Route Policy for L2VPN VPLS with BGP Autodiscovery

Perform this task to enable route-policy for L2VPN VPLS with BGP autodiscovery configuration. Only route-policy export is supported.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge group name*
4. **bridge-domain** *bridge-domain name*
5. **vfi** { *vfi-name* }
6. **autodiscovery bgp**
7. **route-policy export** *policy-name*

8. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge group name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group bg1
```

Enters configuration mode for the named bridge group.

Step 4 **bridge-domain** *bridge-domain name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain bd1
```

Enters configuration mode for the named bridge domain.

Step 5 **vfi** { *vfi-name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# vfi vfi-east
```

Enters virtual forwarding instance (VFI) configuration mode.

Step 6 **autodiscovery bgp**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# autodiscovery bgp
```

Enters BGP autodiscovery configuration mode where all BGP autodiscovery parameters are configured.

This command is not provisioned to BGP until at least the VPN ID and the signaling protocol is configured.

Step 7 **route-policy export** *policy-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad)# route-policy export RPL_1
```

Attaches the route-policy at **route-policy export** attach point.

Step 8 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Example

Enabling Route Policy for L2VPN VPWS with BGP Autodiscovery

Perform this task to enable route-policy for L2VPN VPWS with BGP autodiscovery configuration. Only route-policy export is supported.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **xconnect group** *xconnect group name*
4. **mp2mp** *mp2mp instance name*
5. **autodiscovery bgp**
6. **route-policy export** *policy-name*
7. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **xconnect group** *xconnect group name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group xg1
```

Enters configuration mode for the named cross-connect group.

Step 4 **mp2mp** *mp2mp instance name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc)# mp2mp mp1
```

Creates named mp2mp instance.

Step 5 **autodiscovery bgp**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-mp2mp)# autodiscovery bgp
```

Enters BGP autodiscovery configuration mode where all BGP autodiscovery parameters are configured.

This command is not provisioned to BGP until at least the VPN ID and the signaling protocol is configured.

Step 6 **route-policy export** *policy-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-mp2mp-ad)# route-policy export RPL_2
```

Attaches the route-policy at **route-policy export** attach point.

Step 7 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Example

Configuring G.8032 Ethernet Ring Protection

To configure the G.8032 operation, separately configure:

- An ERP instance to indicate:
  - which (sub)interface is used as the APS channel
  - which (sub)interface is monitored by CFM
  - whether the interface is an RPL link, and, if it is, the RPL node type
- CFM with EFD to monitor the ring links

Note MEP for each monitor link needs to be configured with different Maintenance Association.

- The bridge domains to create the Layer 2 topology. The RAPS channel is configured in a dedicated management bridge domain separated from the data bridge domains.
- Behavior characteristics, that apply to ERP instance, if different from default values. This is optional.

This section provides information on:

Configuring ERP Profile

Perform this task to configure Ethernet ring protection (ERP) profile.

SUMMARY STEPS

1. **configure**
2. **Ethernet ring g8032 profile** *profile-name*
3. **timer** { **wtr** | **guard** | **hold-off** } *seconds*
4. **non-revertive**
5. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **Ethernet ring g8032 profile** *profile-name*

Example:

```
RP/0/RSP0/CPU0:router(config)# Ethernet ring g8032 profile p1
```

Enables G.8032 ring mode, and enters G.8032 configuration submode.

Step 3 **timer** { **wtr** | **guard** | **hold-off** } *seconds*

Example:

```
RP/0/RSP0/CPU0:router(config-g8032-ring-profile)# timer hold-off 5
```

Specifies time interval (in seconds) for the guard, hold-off and wait-to-restore timers.

Step 4 **non-revertive**

Example:

```
RP/0/RSP0/CPU0:router(config-g8032-ring-profile)# non-revertive
```

Specifies a non-revertive ring instance.

Step 5 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring CFM MEP

For more information about Ethernet Connectivity Fault Management (CFM), refer to the *Configuring Ethernet OAM on the Cisco ASR 9000 Series Router* module in the Cisco *ASR 9000 Series Aggregation Services Router Interface and Hardware Component Configuration Guide*.

Configuring an ERP Instance

Perform this task to configure an ERP instance.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *domain-name*
5. **interface** *type port0-interface-path-id.subinterface*
6. **interface** *type port1-interface-path-id.subinterface*
7. **bridge-domain** *domain-name*
8. **interface** *type interface-path-id.subinterface*
9. **ethernet ring g8032** *ring-name*

10. **instance** *number*
11. **description** *string*
12. **profile** *profile-name*
13. **rpl { port0 | port1 } { owner | neighbor | next-neighbor }**
14. **inclusion-list vlan-ids** *vlan-id*
15. **aps-channel**
16. **level** *number*
17. **port0 interface** *type path-id*
18. **port1** { **interface** *type interface-path-id* | **bridge-domain** *bridge-domain-name* | **xconnect** *xconnect-name* | **none** }
19. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group that can contain bridge domains, and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain bd1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain for R-APS channels, and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **interface** *type port0-interface-path-id.subinterface*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# interface GigabitEthernet 0/0/0/0.1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#
```

Enters interface configuration mode and adds an interface to a bridge domain that allows packets to be forwarded and received from other interfaces that are part of the same bridge domain.

Step 6 **interface** *type port1-interface-path-id.subinterface*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# interface GigabitEthernet 0/0/0/1.1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#
```

Enters interface configuration mode and adds an interface to a bridge domain that allows packets to be forwarded and received from other interfaces that are part of the same bridge domain.

Step 7 **bridge-domain** *domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain bd2
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain for data traffic, and enters L2VPN bridge group bridge domain configuration mode.

Step 8 **interface** *type interface-path-id.subinterface*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# interface GigabitEthernet 0/0/0/0.10
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#
```

Enters interface configuration mode and adds an interface to a bridge domain that allows packets to be forwarded and received from other interfaces that are part of the same bridge domain.

Step 9 **ethernet ring g8032** *ring-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# ethernet ring g8032 r1
```

Enables G.8032 ring mode, and enters G.8032 configuration submode.

Step 10 **instance** *number*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp)# instance 1
```

Enters the Ethernet ring G.8032 instance configuration submode.

Step 11 **description** *string*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp-instance)# description test
```

Specifies a string that serves as description for that instance.

Step 12 **profile** *profile-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp-instance)#profile p1
```

Specifies associated Ethernet ring G.8032 profile.

Step 13 **rpl { port0 | port1 } { owner | neighbor | next-neighbor }**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp-instance)#rpl port0 neighbor
```

Specifies one ring port on local node as RPL owner, neighbor or next-neighbor.

Step 14 **inclusion-list vlan-ids** *vlan-id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp-instance)# inclusion-list vlan-ids e-g
```

Associates a set of VLAN IDs with the current instance.

Step 15 **aps-channel**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp-instance)# aps-channel
```

Enters the Ethernet ring G.8032 instance aps-channel configuration submode.

Step 16 **level** *number*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp-instance-aps)# level 5
```

Specifies the APS message level. The range is from 0 to 7.

Step 17 **port0 interface** *type path-id*

Example:

```
RP/0/RSP0/CPU0:router(configl2vpn-erp-instance-aps)# port0 interface GigabitEthernet 0/0/0/0.1
```

Associates G.8032 APS channel interface to port0.

Step 18 **port1** { **interface** *type interface-path-id* | **bridge-domain** *bridge-domain-name* | **xconnect** *xconnect-name* | **none** }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp-instance-aps)# port1 interface GigabitEthernet 0/0/0/1.1
```

Associates G.8032 APS channel interface to port1.

Step 19 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring ERP Parameters

Perform this task to configure ERP parameters.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **ethernet ring g8032** *ring-name*
4. **port0 interface** *type interface-path-id*
5. **monitor port0 interface** *type interface-path-id*
6. **exit**
7. **port1** { **interface** *type interface-path-id* | **virtual** | **none**}
8. **monitor port1 interface** *type interface-path-id*
9. **exit**
10. **exclusion-list vlan-ids** *vlan-id*
11. **open-ring**
12. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **ethernet ring g8032** *ring-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# ethernet ring g8032 r1
```

Enables G.8032 ring mode, and enters G.8032 configuration submode.

Step 4 **port0 interface** *type interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp)# port0 interface GigabitEthernet 0/1/0/6
```

Enables G.8032 ERP for the specified port (ring port).

Step 5 **monitor port0 interface** *type interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp-port0)# monitor port0 interface 0/1/0/2
```

Specifies the port that is monitored to detect ring link failure per ring port. The monitored interface must be a sub-interface of the main interface.

Step 6 **exit**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp-port0)# exit
```

Exits port0 configuration submode.

Step 7 **port1** { **interface** *type interface-path-id* | **virtual** | **none**}

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp)# port1 interface GigabitEthernet 0/1/0/8
```

Enables G.8032 ERP for the specified port (ring port).

Step 8 **monitor port1 interface** *type interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp-port1)# monitor port1 interface 0/1/0/3
```

Specifies the port that is monitored to detect ring link failure per ring port. The monitored interface must be a sub-interface of the main interface.

Step 9 **exit**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp-port1)# exit
```

Exits port1 configuration submode.

Step 10 **exclusion-list vlan-ids** *vlan-id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp)# exclusion-list vlan-ids a-d
```

Specifies a set of VLAN IDs that is not protected by Ethernet ring protection mechanism.

Step 11 **open-ring**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-erp)# open-ring
```

Specifies Ethernet ring G.8032 as open ring.

Step 12 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring TCN Propagation

Perform this task to configure topology change notification (TCN) propagation.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **tcn-propagation**
4. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **tcn-propagation**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# tcn-propagation
```

Allows TCN propagation from minor ring to major ring and from MSTP to G.8032.

Step 4 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring Flow Aware Transport Pseudowire

This section provides information on

Enabling Load Balancing with ECMP and FAT PW for VPWS

Perform this task to enable load balancing with ECMP and FAT PW for VPWS. Creating a PW-Class in L2VPN configuration leads to load-balancing.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **pw-class** { *name* }
4. **encapsulation mpls**
5. **load-balancing flow-label** { **both** | **code** | **receive** | **transmit** } [**static**]
6. **exit**
7. **exit**
8. **xconnect group** *group-name*
9. **p2p** *xconnect-name*
10. **interface type** *interface-path-id*
11. **neighbor** *A.B.C.D* **pw-id** pseudowire-id
12. **pw-class** *class-name*
13. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **pw-class** { *name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# pw-class path1
```

Configures the pseudowire class template name to use for the pseudowire.

Step 4 **encapsulation mpls**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-pwc)# encapsulation mpls
```

Configures the pseudowire encapsulation to MPLS.

Step 5 **load-balancing flow-label** { **both** | **code** | **receive** | **transmit** } [**static**]

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-pwc-mpls)# load-balancing flow-label both
```

Enables load-balancing on ECMPs. Also, enables the imposition and disposition of flow labels for the pseudowire.

Note If the static keyword is not specified, end to end negotiation of the FAT PW is enabled.

Step 6 **exit**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-pwc-mpls)#exit
RP/0/RSP0/CPU0:router(config-l2vpn-pwc)#
```

Exits the pseudowire encapsulation submode and returns the router to the parent configuration mode.

Step 7 **exit**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-pwc)#exit
RP/0/RSP0/CPU0:router(config-l2vpn)#
```

Exits the pseudowire submode and returns the router to the l2vpn configuration mode.

Step 8 **xconnect group** *group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group grp1
RP/0/RSP0/CPU0:router(config-l2vpn-xc)#
```

Specifies the name of the cross-connect group.

Step 9 **p2p** *xconnect-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p vlan1
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)#
```

Specifies the name of the point-to-point cross-connect.

Step 10 **interface type** *interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface TenGigE 0/0/0/0.1
```

Specifies the interface type and instance.

Step 11 **neighbor** *A.B.C.D* **pw-id** pseudowire-id

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# neighbor 10.2.2.2 pw-id 2000
```

Configures the pseudowire segment for the cross-connect.

Use the A.B.C.D argument to specify the IP address of the cross-connect peer.

Note A.B.C.D can be a recursive or non-recursive prefix.

Step 12 **pw-class** *class-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# pw-class path1
```

Associates the pseudowire class with this pseudowire.

Step 13 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Enabling Load Balancing with ECMP and FAT PW for VPLS

Perform this task to enable load balancing with ECMP and FAT PW for VPLS.

SUMMARY STEPS

1. **configure**
2. **l2vpn**

3. **load-balancing flow {src-dst-mac | src-dst-ip}**
4. **pw-class** { *class - name* }
5. **encapsulation mpls**
6. **load-balancing flow-label** { **both** | **code** | **receive** | **transmit** } [**static**]
7. **exit**
8. **bridge group** *bridge-group-name*
9. **bridge-domain** *bridge-domain-name*
10. **vfi** { *vfi-name* }
11. **autodiscovery bgp**
12. **signaling-protocol bgp**
13. **load-balancing flow-label** { **both** | **code** | **receive** | **transmit** } [**static**]
14. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **load-balancing flow {src-dst-mac | src-dst-ip}**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# load-balancing flow src-dst-ip
```

Enables flow based load balancing.

- **src-dst-mac**—Uses source and destination MAC addresses for hashing.
- **src-dst-ip**—Uses source and destination IP addresses for hashing.

Note It is recommended to use the **load-balancing flow** command with the **src-dst-ip** keyword.

Step 4 **pw-class** { *class - name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# pw-class class1
```

Associates the pseudowire class with this pseudowire.

Step 5 **encapsulation mpls**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-pwc)# encapsulation mpls
```

Configures the pseudowire encapsulation to MPLS.

Step 6 **load-balancing flow-label** { **both** | **code** | **receive** | **transmit** } [**static**]

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-pwc-mpls)# load-balancing flow-label both
```

Enables load-balancing on ECMPs. Also, enables the imposition and disposition of flow labels for the pseudowire.

Note If the **static** keyword is not specified, end to end negotiation of the **FAT PW** is enabled.

Step 7 **exit**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-pwc-mpls)# exit
```

Exits the pseudowire encapsulation submode and returns the router to the parent configuration mode.

Step 8 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group group1
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 9 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain domain1
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 10 **vfi** { *vfi-name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# vfi my_vfi
```

Enters virtual forwarding instance (VFI) configuration mode.

Step 11 **autodiscovery bgp**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# autodiscovery bgp
```

Enters BGP autodiscovery configuration mode where all BGP autodiscovery parameters are configured.

Step 12 **signaling-protocol bgp**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad)# signaling-protocol bgp
```

Enables BGP signaling, and enters the BGP signaling configuration submode where BGP signaling parameters are configured.

Step 13 **load-balancing flow-label** { **both** | **code** | **receive** | **transmit** } [**static**]

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad-sig)# load-balancing flow-label both static
```

Enables load-balancing on ECMPs. Also, enables the imposition and disposition of flow labels for the pseudowire.

Step 14 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring Pseudowire Headend

The Pseudowire Headend (PWHE) is created by configuring the pw-ether main interface, pw-ether subinterface, or pw-iw interface. The available PWHE types are pw-ether main interfaces, subinterfaces, and pw-iw interfaces. Unless specified otherwise, the term interface is applicable for pw-ether main interfaces, subinterfaces, and pw-iw interfaces.

Note The PWHE-Ethernet subinterfaces and interworking interfaces are supported from Release 5.1.1 onwards.

For the PWHE to be functional, the crossconnect has to be configured completely. Configuring other Layer 3 (L3) parameters, such as VRF and IP addresses, are optional for the PWHE to be functional. However, the L3 features are required for the Layer 3 services to be operational; that is, for PW L3 termination.

PWHE supports both IPv4 and IPv6 addresses.

This section describes these topics:

PWHE Configuration Restrictions

These configuration restrictions are applicable for PWHE:

1. The generic interface list members must be the superset of the ECMP path list to the A-PE.

2. Only eight generic interface lists are supported per A-PE neighbor address.
3. Eight Layer 3 links per generic interface list are supported.
4. Only PW-Ether interfaces can be configured as PWHE L2 or L3 subinterfaces.
5. Cross-connects that contain PW-Ether main interfaces can be configured as either VC-type 5 or VC-type 4. By default, the cross-connects are configured as VC-type 5; else by using the command—pw-class transport-mode ethernet. To configure the cross-connects as VC-type 4, use the **p2p neighbor tag-impose vlan id** and the **pw-class transport-mode vlan** commands.
6. Cross-connects that contain PW-Ether main interfaces that have L3 PW-Ether subinterfaces associated with them, are supported with only VC-type 5.
7. Cross-connects that contain PW-IW interfaces are only supported with IPv4 and VC-type 11. PW-IW interfaces are the L3 virtual interfaces used for IP interworking. To configure the cross-connect as VC-type 11, use the interworking ipv4 command.
8. PW-Ether interfaces and subinterfaces can be configured with both IPv4 and IPv6.
9. PW-IW interfaces can be configured only with IPv4.
10. Pseudowire redundancy, preferred path, local switching or L2TP are not supported for crossconnects configured with PWHE.
11. Applications such as TE and LDP have checks for interface type and therefore do not allow PWHE to be configured.
12. Address family, CDP and MPLS configurations are not allowed on PWHE interfaces.
13. For PWHE, eBGP, static routes, OSPF, and ISIS are supported with both IPv4 and IPv6. RIP is only supported with IPv4 and not with IPv6.
14. MAC address is not supported for a pw-iw interface.
15. PW-Ether interfaces with different remote neighbors need to be attached with a different generic interface list. Hence, you must create a separate and dedicated generic interface list for each remote neighbor or peer whose remote neighbors are different routers or devices. For example, in Figure 12: Pseudowire Network, for each A-PE that the S-PE peers with, a unique generic interface list needs to be configured. The generic interface list may have the same set of the outgoing interface(s).
16. Refer PWHE Load Balancing Support using FAT Label topic for the feature's restrictions.

Configuring Generic Interface List

Perform this task to configure a generic interface list.

Note Only eight generic interface lists are supported per A-PE neighbor address. Eight Layer 3 links per generic interface list are supported. Repeat Step 3 or Step 4 to add the interfaces to the generic interface list.

SUMMARY STEPS

1. **configure**
2. **generic-interface-list** *list-name*
3. **interface** *type interface-path-id*
4. **interface** *type interface-path-id*
5. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **generic-interface-list** *list-name*

Example:

```
RP/0/RSP0/CPU0:router(config)# generic-interface-list list1
```

Configures a generic interface list.

To remove the generic interface list, use the no form of the command, that is, **no generic-interface-list** *list-name*.

Step 3 **interface** *type interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router(config-if-list)# interface Bundle-Ether 100
```

Configures the specified interface.

Step 4 **interface** *type interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router(config-if-list)# interface Bundle-Ether 200
```

Configures the specified interface.

Step 5 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring PWHE Interfaces

Perform this task to configure PWHE Ethernet and interworking interfaces, that is, to attach the generic interface list with a PWHE Ethernet and interworking interfaces.

SUMMARY STEPS

1. **configure**
2. **interface pw-ether** *id* or **interface pw-iw** *id*
3. **attach generic-interface-list** *interface_list_name*

4. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **interface pw-ether** *id* or **interface pw-iw** *id*

Example:

```
RP/0/RSP0/CPU0:router(config)# interface pw-ether <id>
or
RP/0/RSP0/CPU0:router(config)# interface pw-iw <id>
```

(**interface pw-ether** *id*) Configures the PWHE pseudowire main or subinterface and enters the interface configuration mode.

(**interface pw-iw** *id*) Configures the PWHE pseudowire interworking interface and enters the interface configuration mode.

Step 3 **attach generic-interface-list** *interface_list_name*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# attach generic-interface-list interfacelist1
```

Attaches the generic interface list to the PW-Ether or PW-IW interface . To remove the generic interface list from the PW-Ether or PW-IW interface, use the **no** form of the command, that is, **no generic-interface-list** *list-name*

Step 4 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring PWHE Crossconnect

Perform this task to configure PWHE crossconnects.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **xconnect group** *group-name*

4. **p2p** *xconnect-name*
5. **interface pw-ether** *id* or **interface pw-iw** *id*
6. **neighbor** *ip-address* **pw-id** *value*
7. **pw-class** *class-name*
8. (*Only PW-IW*) **interworking ipv4**
9. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters Layer 2 VPN configuration mode.

Step 3 **xconnect group** *group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group pw-he1
```

Configures a cross-connect group name using a free-format 32-character string.

Step 4 **p2p** *xconnect-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p pw-hexconnect
```

Enters P2P configuration submode.

Step 5 **interface pw-ether** *id* or **interface pw-iw** *id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface pw-ether 100
or
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p )# interface pw-iw 100
```

Configures the PWHE interface.

Step 6 **neighbor** *ip-address* **pw-id** *value*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# neighbor 10.165.200.25 pw-id 100
```

Configures a pseudowire for a cross-connect.

The IP address is that of the corresponding PE node.

The **pw-id** must match the **pw-id** of the PE node.

Step 7 **pw-class** *class-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# pw-class dynamic_mpls
```

Enters pseudowire class submode, allowing you to define a pseudowire class template.

Note The pseudowire class should be defined under l2vpn for VC4 and VC5 as follows:

```
pw-class vc_type_4
encapsulation mpls
transport-mode vlan
!
!
pw-class vc_type_5
encapsulation mpls
transport-mode ethernet
!
!
```

Step 8 (*Only PW-IW*) **interworking ipv4**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# interworking ipv4
```

Configures the cross-connect p2p entity to use VC-type 11 or the IP interworking mode in the establishment of the pseudowire.

Step 9 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring the Source Address

Perform this task to configure the local source address

Note Only IPv4 is supported as pw-class source address.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **pw-class** *class-name*
4. **encapsulation mpls**
5. **ipv4 source** *source-address*
6. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters Layer 2 VPN configuration mode.

Step 3 **pw-class** *class-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# pw-class class1
```

Enters pseudowire class submode, allowing you to define a pseudowire class template.

Step 4 **encapsulation mpls**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-pwc)# encapsulation mpls
```

Configures the pseudowire encapsulation to MPLS.

Step 5 **ipv4 source** *source-address*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-pwc-mpls)# ipv4 source 10.1.1.1
```

Sets the local source IPv4 address.

Step 6 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring PWHE Interface Parameters

Perform this task to configure PWHE interface parameters.

SUMMARY STEPS

1. **configure**
2. **interface pw-ether** *id* (or) **interface pw-iw** *id*
3. **ipv4 address** *ip-address subnet-mask* (or) (Only PW-Ether) **ipv6 address** *ipv6-prefix/prefix-length*
4. **attach generic-interface-list** *interface_list_name*
5. **l2overhead** *bytes*
6. **load-interval** *seconds*
7. **dampening** *decay-life*
8. **logging events link-status**
9. (Only PW-Ether main interfaces) **mac-address** *MAC address*
10. **mtu** *interface_MTU*
11. **bandwidth** *kbps*
12. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **interface pw-ether** *id* (or) **interface pw-iw** *id*

Example:

```
RP/0/RSP0/CPU0:router(config)# interface pw-ether <id>
or
RP/0/RSP0/CPU0:router(config)# interface pw-iw <id>
```

(**interface pw-ether** *id*) Configures the PWHE interface and enters the interface configuration mode.

(**interface pw-iw** *id*) Configures the PWHE interface and enters the interface configuration mode.

Step 3 **ipv4 address** *ip-address subnet-mask* (or) (Only PW-Ether) **ipv6 address** *ipv6-prefix/prefix-length*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 40.1.1.2 255.255.255.0
```

Sets the IPv4 or IPv6 address of the interface.

Step 4 **attach generic-interface-list** *interface_list_name*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# attach generic-interface-list interfacelist1
```

Attaches the generic interface list to the PW-Ether or PW-IW interface.

Step 5 **l2overhead** *bytes*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# l2overhead 20
```

Sets layer 2 overhead size.

Step 6 **load-interval** *seconds*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# load-interval 90
```

Specifies interval, in seconds, for load calculation for an interface.

The interval:

- Can be set to 0 [0 disables load calculation]
- If not 0, must be specified in multiples of 30 between 30 and 600.

Step 7 **dampening** *decay-life*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# dampening 10
```

Configures state dampening on the given interface (in minutes).

Step 8 **logging events link-status**

Example:

```
RP/0/RSP0/CPU0:router(config-if)# logging events link-status
```

Configures per interface logging.

Step 9 (Only PW-Ether main interfaces) **mac-address** *MAC address*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# mac-address aaaa.bbbb.cccc
```

Sets the MAC address (xxxx.xxxx.xxxx) on an interface.

Step 10 **mtu** *interface_MTU*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# mtu 128
```

Sets the MTU on an interface.

Step 11 **bandwidth** *kbps*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# bandwidth 200
```

Configures the bandwidth. The range is from 0 to 4294967295.

Step 12 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring PWHE Layer 2 Subinterfaces and Adding it to the Bridge-domain

Perform this task to configure PWHE layer 2 subinterfaces and add it to the bridge-domain.

Note A Layer 2 subinterface does not contain an IP address and must be configured to operate in the Layer 2 transport mode.

SUMMARY STEPS

1. **configure**
2. **interface pw-ether** *id*
3. **ipv4 address** *ip-address subnet-mask* (or) **ipv6 address** *ipv6-prefix/prefix-length*
4. **attach generic-interface-list** *interface_list_name*
5. **interface pw-ether** *id.subintfid* **l2transport**
6. **encapsulation dot1q** *value*
7. **l2vpn**
8. **xconnect group** *group-name*
9. **p2p** *xconnect-name*
10. **interface pw-ether** *id*
11. **neighbor ipv4** *ip-address* **pw-id** *value*
12. **bridge group** *bridge-group-name*
13. **bridge-domain** *bridge-domain-name*
14. **interface pw-ether** *id.subintfid*
15. **interface** *type interface-path-id*
16. **neighbor** *ip-address* **pw-id** *value*
17. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **interface pw-ether** *id*

Example:

```
RP/0/RSP0/CPU0:router(config)# interface PW-Ether1
```

Configures the PWHE interface and enters the interface configuration mode.

Step 3 **ipv4 address** *ip-address subnet-mask* (or) **ipv6 address** *ipv6-prefix/prefix-length*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 40.1.1.2 255.255.255.0
```

Sets the IPv4 or IPv6 address of the main interface.

Step 4 **attach generic-interface-list** *interface_list_name*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# attach generic-interface-list pw_he
```

Attaches the generic interface list to the interface.

Step 5 **interface pw-ether** *id.subintfid* **l2transport**

Example:

```
RP/0/RSP0/CPU0:router(config-if)# interface PW-Ether1.1 l2transport
```

Configures the PWHE sub-interface and enters the sub-interface configuration mode.

Step 6 **encapsulation dot1q** *value*

Example:

```
RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 1
```

Defines the matching criteria to map 802.1Q frames ingress on an interface to the appropriate service instance.

Step 7 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config-subif)# l2vpn
```

Enters Layer 2 VPN configuration mode.

Step 8 **xconnect group** *group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group xg
```

Configures a cross-connect group name using a free-format 32-character string.

Step 9 **p2p** *xconnect-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p1
```

Enters P2P configuration submode.

Step 10 **interface pw-ether** *id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface PW-Ether1
```

Configures the PWHE interface.

Step 11 **neighbor ipv4** *ip-address* **pw-id** *value*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# neighbor ipv4 1.1.1.1 pw-id 1
```

Configures a pseudowire for a cross-connect.

The IP address is that of the corresponding A-PE node.

The pw-id must match the pw-id of the A-PE node.

Step 12 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# bridge group bg
```

Creates a bridge group that can contain bridge domains, and then assigns network interfaces to the bridge domain.

Step 13 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain bd1
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 14 **interface pw-ether** *id.subintfid*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# interface PW-Ether1.1
```

Adds the subinterface to the bridge domain.

Step 15 **interface** *type interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# interface GigabitEthernet0/1/1/11.1
```

Enters interface configuration mode and adds a subinterface to a bridge domain that allows packets to be forwarded and received from other interfaces that are part of the same bridge domain.

Step 16 **neighbor** *ip-address* **pw-id** *value*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# neighbor 3.3.3.3 pw-id 101
```

Configures a pseudowire for a bridge-domain.

Step 17 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring PWHE Layer 3 Subinterfaces

Perform this task to configure PWHE layer 3 subinterfaces.

Note A layer 3 subinterface must have an IPv4 or IPv6 address and cannot be configured in the layer 2 transport mode.

SUMMARY STEPS

1. **configure**
2. **interface pw-ether** *id*
3. **ipv4 address** *ip-address subnet-mask* (or) **ipv6 address** *ipv6-prefix/prefix-length*
4. **attach generic-interface-list** *interface_list_name*

5. **interface pw-ether** *id.subintfid*
6. **ipv4 address** *ip-address subnet-mask* (or) **ipv6 address** *ipv6-prefix/prefix-length*
7. **encapsulation dot1q** *value*
8. **l2vpn**
9. **xconnect group** *group-name*
10. **p2p** *group-name*
11. **interface pw-ether** *id*
12. **neighbor ipv4** *ip-address* **pw-id** *value*

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **interface pw-ether** *id*

Example:

```
RP/0/RSP0/CPU0:router(config)# interface PW-Ether1
```

Configures the PWHE interface and enters the interface configuration mode.

Step 3 **ipv4 address** *ip-address subnet-mask* (or) **ipv6 address** *ipv6-prefix/prefix-length*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 40.1.1.2 255.255.255.0
```

Sets the IPv4 or the IPv6 address of the main interface.

Step 4 **attach generic-interface-list** *interface_list_name*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# attach generic-interface-list pw_he
```

Attaches the generic interface list to the interface.

Step 5 **interface pw-ether** *id.subintfid*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# interface PW-Ether1.1
```

Configures the PWHE sub-interface and enters the sub-interface configuration mode.

Step 6 **ipv4 address** *ip-address subnet-mask* (or) **ipv6 address** *ipv6-prefix/prefix-length*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 40.1.1.2 255.255.255.0
```

Sets the IPv4 or the IPv6 address of the subinterface.

Step 7 **encapsulation dot1q** *value*

Example:

```
RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 1
```

Defines the matching criteria to map 802.1Q frames ingress on an interface to the appropriate service instance.

Step 8 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config-subif)# l2vpn
```

Enters Layer 2 VPN configuration mode.

Step 9 **xconnect group** *group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group xg
```

Configures a cross-connect group name using a free-format 32-character string.

Step 10 **p2p** *group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p 1
```

Enters P2P configuration submode.

Step 11 **interface pw-ether** *id*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface PW-Ether1
```

Configures the PWHE interface.

Step 12 **neighbor ipv4** *ip-address* **pw-id** *value*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# neighbor ipv4 1.1.1.1 pw-id 1
```

Configures a pseudowire for a cross-connect.

The IP address is that of the corresponding A-PE node.

The **pw-id** must match the **pw-id** of the A-PE node.

Configuring L2VPN over GRE

Perform these tasks to configure L2VPN over GRE.

SUMMARY STEPS

1. **configure**
2. **interface type** *interface-path-id*
3. **l2transport**
4. **exit**
5. **interface loopback instance**
6. **ipv4 address ip-address**
7. **exit**
8. **interface loopback** *instance*
9. **ipv4 address** *ip-address*
10. **router ospf** *process-name*
11. **area** *area-id*
12. **interface loopback** *instance*
13. **interface tunnel-ip** *number*
14. **exit**
15. **interface tunnel-ip** *number*
16. **ipv4 address** *ipv4-address subnet-mask*
17. **tunnel source** *type path-id*
18. **tunnel destination** *ip-address*
19. **end**
20. **l2vpn**
21. **bridge group** *bridge-group-name*
22. **bridge-domain** *bridge-domain-name*
23. **interface type** *interface-path-id*
24. **neighbor** { *A.B.C.D* } { **pw-id** *value* }
25. **mpls ldp**
26. **router-id** { *router-id* }
27. **interface tunnel-ip** *number*
28. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **interface type** *interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router# interface TenGigE0/1/0/12
```

Enters interface configuration mode and configures an interface.

Step 3 **l2transport**

Example:

```
RP/0/RSP0/CPU0:router# l2transport
```

Enables Layer 2 transport on the selected interface.

Step 4 **exit**

Example:

```
RP/0/RSP0/CPU0:router# exit
```

Exits the current configuration mode.

Step 5 **interface loopback instance**

Example:

```
RP/0/RSP0/CPU0:router# interface Loopback0
```

Enters interface configuration mode and names the new loopback interface.

Step 6 **ipv4 address ip-address**

Example:

```
RP/0/RSP0/CPU0:router# ipv4 address 100.100.100.100 255.255.255.255
```

Assigns an IP address and subnet mask to the virtual loopback interface.

Step 7 **exit**

Example:

```
RP/0/RSP0/CPU0:router# exit
```

Exits the current configuration mode.

Step 8 **interface loopback** *instance*

Example:

```
RP/0/RSP0/CPU0:router# interface Loopback1
```

Enters interface configuration mode and names the new loopback interface.

Step 9 **ipv4 address** *ip-address*

Example:

```
RP/0/RSP0/CPU0:router# ipv4 address 10.0.1.1 255.255.255.255
```

Assigns an IP address and subnet mask to the virtual loopback interface.

Step 10 **router ospf** *process-name*

Example:

```
RP/0/RSP0/CPU0:router# router ospf 1
```

Enables OSPF routing for the specified routing process and places the router in router configuration mode.

Step 11 **area** *area-id*

Example:

```
RP/0/RSP0/CPU0:router# area 0
```

Enters area configuration mode and configures an area for the OSPF process.

Step 12 **interface loopback** *instance*

Example:

```
RP/0/RSP0/CPU0:router# interface Loopback0
```

Enters interface configuration mode and names the new loopback interface.

Step 13 **interface tunnel-ip** *number*

Example:

```
RP/0/RSP0/CPU0:router# interface tunnel-ip1
```

Enters tunnel interface configuration mode.

Step 14 **exit**

Example:

```
RP/0/RSP0/CPU0:router# exit
```

Exits the current configuration mode.

Step 15 **interface tunnel-ip** *number*

Example:

```
RP/0/RSP0/CPU0:router(config)# interface tunnel-ip1
```

Enters tunnel interface configuration mode.

- number is the number associated with the tunnel interface.

Step 16 **ipv4 address** *ipv4-address subnet-mask*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# ipv4 address 12.0.0.1 255.255.255.0
```

Specifies the IPv4 address and subnet mask for the interface.

- ipv4-address specifies the IP address of the interface.
- subnet-mask specifies the subnet mask of the interface.

Step 17 **tunnel source** *type path-id*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# tunnel source Loopback1
```

Specifies the source of the tunnel interface.

Step 18 **tunnel destination** *ip-address*

Example:

```
RP/0/RSP0/CPU0:router(config-if)# tunnel destination 100.100.100.20
```

Defines the tunnel destination.

Step 19 **end**

Example:

```
RP/0/RSP0/CPU0: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.
  - 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.

Step 20 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router# l2vpn
```

Enters L2VPN configuration mode.

Step 21 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router# bridge group access-pw
```

Creates a bridge group that can contain bridge domains, and then assigns network interfaces to the bridge domain.

Step 22 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router# bridge-domain test
```

Establishes a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 23 **interface type** *interface-path-id*

Example:

```
RP/0/RSP0/CPU0:router# interface TenGigE0/1/0/12
```

Enters interface configuration mode and adds an interface to a bridge domain that allows packets to be forwarded and received from other interfaces that are part of the same bridge domain.

Step 24 **neighbor** { *A.B.C.D* } { **pw-id** *value* }

Example:

```
RP/0/RSP0/CPU0:router# neighbor 125.125.125.125 pw-id 100
```

Adds an access pseudowire port to a bridge domain or a pseudowire to a bridge virtual forwarding interface (VFI).

- Use the A.B.C.D argument to specify the IP address of the cross-connect peer

  Note A.B.C.D can be a recursive or non-recursive prefix.

- Use the pw-id keyword to configure the pseudowire ID and ID value. The range is 1 to 4294967295.

Step 25 **mpls ldp**

Example:

```
RP/0/RSP0/CPU0:router# mpls ldp
```

Enables MPLS LDP configuration mode.

Step 26 **router-id** { *router-id* }

Example:

```
RP/0/RSP0/CPU0:router# router-id 100.100.100.100
```

Configures a router ID for the OSPF process.

Note We recommend using a stable IP address as the router ID.

Step 27 **interface tunnel-ip** *number*

Example:

```
RP/0/RSP0/CPU0:router# interface tunnel-ip1
```

Enters tunnel interface configuration mode.

Note The number argument refers to the number associated with the tunnel interface

Step 28 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuring a GRE Tunnel as Preferred Path for Pseudowire

Perform this task to configure a GRE tunnel as the preferred path for pseudowires.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **pw-class** { *name* }
4. **encapsulation mpls**
5. **preferred-path** { **interface** } { **tunnel-ip** *value* | **tunnel-te** *value* | **tunnel-tp** *value* } [**fallback disable**]
6. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **pw-class** { *name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# pw-class gre
```

Configures the pseudowire class name.

Step 4 **encapsulation mpls**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-pwc)# encapsulation mpls
```

Configures the pseudowire encapsulation to MPLS.

Step 5 **preferred-path** { **interface** } { **tunnel-ip** *value* | **tunnel-te** *value* | **tunnel-tp** *value* } [**fallback disable**]

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-pwc-encap-
mpls)# preferred-path interface tunnel-ip 1 fallback disable
```

Configures preferred path tunnel settings. If the fallback disable configuration is used and once the TE/TP tunnel is configured as the preferred path goes down, the corresponding pseudowire can also go down.

Note Ensure that fallback is supported.

Step 6 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.

- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Configuration Examples for Multipoint Layer 2 Services

This section includes these configuration examples:

Multipoint Layer 2 Services Configuration for Provider Edge-to-Provider Edge: Example

These configuration examples show how to create a Layer 2 VFI with a full-mesh of participating Multipoint Layer 2 Services provider edge (PE) nodes.

This configuration example shows how to configure PE 1:

```
configure
 l2vpn
  bridge group 1
   bridge-domain PE1-VPLS-A
    interface TenGigE0/0/0/0
    vfi 1
     neighbor 172.16.0.1 pw-id 1
     neighbor 192.168.0.1 pw-id 1
     !
   !
 interface loopback 0
  ipv4 address 10.0.0.1 255.0.0.0
```

This configuration example shows how to configure PE 2:

```
configure
 l2vpn
  bridge group 1
   bridge-domain PE2-VPLS-A
    interface TenGigE0/0/0/1

    vfi 1
     neighbor 10.0.0.1 pw-id 1
     neighbor 192.168.0.1 pw-id 1
     !
   !
 interface loopback 0
  ipv4 address 172.16.0.1 255.240.0.0
```

This configuration example shows how to configure PE 3:

```
configure
 l2vpn
  bridge group 1
   bridge-domain PE3-VPLS-A
    interface TenGigE0/0/0/2
    vfi 1
     neighbor 10.0.0.1 pw-id 1
     neighbor 172.16.0.1 pw-id 1
     !
   !
 interface loopback 0
  ipv4 address 192.168.0.1 255.255.0.0
```

Multipoint Layer 2 Services Configuration for Provider Edge-to-Customer Edge: Example

This configuration shows how to configure Multipoint Layer 2 Services for a PE-to-CE nodes:

```
configure
 interface TenGigE0/0/0/0
  l2transport---AC interface

  no ipv4 address
  no ipv4 directed-broadcast
  negotiation auto
  no cdp enable
```

Displaying MAC Address Withdrawal Fields: Example

This sample output shows the MAC address withdrawal fields:

```
RP/0/RSP0/CPU0:router# show l2vpn bridge-domain detail

Legend: pp = Partially Programmed.
Bridge group: 222, bridge-domain: 222, id: 0, state: up, ShgId: 0, MSTi: 0
  Coupled state: disabled
  MAC learning: enabled
  MAC withdraw: enabled
    MAC withdraw sent on: bridge port up
    MAC withdraw relaying (access to access): disabled
  Flooding:
    Broadcast & Multicast: enabled
    Unknown unicast: enabled
  MAC aging time: 300 s, Type: inactivity
  MAC limit: 4000, Action: none, Notification: syslog
  MAC limit reached: no
  MAC port down flush: enabled
  MAC Secure: disabled, Logging: disabled
  Split Horizon Group: none
  Dynamic ARP Inspection: disabled, Logging: disabled
  IP Source Guard: disabled, Logging: disabled
  DHCPv4 snooping: disabled
  IGMP Snooping: enabled
  IGMP Snooping profile: none
  MLD Snooping profile: none
  Storm Control: disabled
  Bridge MTU: 1500
  MIB cvplsConfigIndex: 1
  Filter MAC addresses:
  P2MP PW: disabled
  Create time: 01/03/2017 11:01:11 (00:21:33 ago)
  No status change since creation
  ACs: 1 (1 up), VFIs: 1, PWs: 1 (1 up), PBBs: 0 (0 up)
  List of ACs:
    AC: TenGigE0/2/0/1.7, state is up
      Type VLAN; Num Ranges: 1
      Outer Tag: 21
      VLAN ranges: [22, 22]
      MTU 1508; XC ID 0x208000b; interworking none
      MAC learning: enabled
      Flooding:
        Broadcast & Multicast: enabled
```

```
        Unknown unicast: enabled
      MAC aging time: 300 s, Type: inactivity
      MAC limit: 4000, Action: none, Notification: syslog
      MAC limit reached: no
      MAC port down flush: enabled
      MAC Secure: disabled, Logging: disabled
      Split Horizon Group: none
      Dynamic ARP Inspection: disabled, Logging: disabled
      IP Source Guard: disabled, Logging: disabled
      DHCPv4 snooping: disabled
      IGMP Snooping: enabled
      IGMP Snooping profile: none
      MLD Snooping profile: none
      Storm Control: bridge-domain policer
      Static MAC addresses:
      Statistics:
        packets: received 714472608 (multicast 0, broadcast 0, unknown unicast 0, unicast
0), sent 97708776
        bytes: received 88594603392 (multicast 0, broadcast 0, unknown unicast 0, unicast
0), sent 12115888224
        MAC move: 0
      Storm control drop counters:
        packets: broadcast 0, multicast 0, unknown unicast 0
        bytes: broadcast 0, multicast 0, unknown unicast 0
      Dynamic ARP inspection drop counters:
        packets: 0, bytes: 0
      IP source guard drop counters:
        packets: 0, bytes: 0
  List of VFIs:
    VFI 222 (up)
      PW: neighbor 10.0.0.1, PW ID 222, state is up ( established )
        PW class not set, XC ID 0xc000000a
        Encapsulation MPLS, protocol LDP
        Source address 21.21.21.21
        PW type Ethernet, control word disabled, interworking none
        Sequencing not set

        PW Status TLV in use
          MPLS         Local                          Remote
          ------------ ------------------------------ ------------------------
          Label        24017                          24010
          Group ID     0x0                            0x0
          Interface    222                            222
          MTU          1500                           1500
          Control word disabled                       disabled
          PW type      Ethernet                       Ethernet
          VCCV CV type 0x2                            0x2
                       (LSP ping verification)        (LSP ping verification)
          VCCV CC type 0x6                            0x6
                       (router alert label)           (router alert label)
                       (TTL expiry)                   (TTL expiry)
          ------------ ------------------------------ ------------------------
        Incoming Status (PW Status TLV):
          Status code: 0x0 (Up) in Notification message
        MIB cpwVcIndex: 3221225482
        Create time: 01/03/2017 11:01:11 (00:21:33 ago)
        Last time status changed: 01/03/2017 11:21:01 (00:01:43 ago)
        Last time PW went down: 01/03/2017 11:15:21 (00:07:23 ago)
        MAC withdraw messages: sent 0, received 0
        Forward-class: 0
        Static MAC addresses:
        Statistics:
          packets: received 95320440 (unicast 0), sent 425092569
          bytes: received 11819734560 (unicast 0), sent 52711478556
```

```
      MAC move: 0
    Storm control drop counters:
      packets: broadcast 0, multicast 0, unknown unicast 0
      bytes: broadcast 0, multicast 0, unknown unicast 0
  DHCPv4 snooping: disabled
  IGMP Snooping profile: none
  MLD Snooping profile: none
  VFI Statistics:
    drops: illegal VLAN 0, illegal length 0
```

Split Horizon Group: Example

This example configures interfaces for Layer 2 transport, adds them to a bridge domain, and assigns them to split horizon groups.

```
RP/0/RSP0/CPU0:router(config)#l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#bridge group examples
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#bridge-domain all_three
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#interface GigabitEthernet 0/0/0/0.99
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#interface GigabitEthernet 0/0/0/0.101
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#split-horizon group
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#neighbor 192.168.99.1 pw-id 1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw)#exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#neighbor 192.168.99.9 pw-id 1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw)#split-horizon group
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw)#exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#vfi abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)#neighbor 192.168.99.17 pw-id 1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)#exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)#exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#show
Mon Oct 18 13:51:05.831 EDT
l2vpn
 bridge group examples
  bridge-domain all_three
   interface GigabitEthernet0/0/0/0.99
   !
   interface GigabitEthernet0/0/0/0.101
    split-horizon group
   !
   neighbor 192.168.99.1 pw-id 1
   !
   neighbor 192.168.99.9 pw-id 1
    split-horizon group
   !
   vfi abc
    neighbor 192.168.99.17 pw-id 1
    !
   !
  !
 !
!

RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

According to this example, the Split Horizon group assignments for bridge domain **all_three** are:

Bridge Port/Pseudowire	Split Horizon Group
bridge port: gig0/0/0/0.99	0
bridge port: gig0/0/0/0.101	2
PW: 192.168.99.1 pw-id 1	0
PW: 192.168.99.9 pw-id 1	2
PW: 192.168.99.17 pw-id 1	1

Blocking Unknown Unicast Flooding: Example

Unknown-unicast flooding can be blocked at these levels:

- bridge domain
- bridge port (attachment circuit (AC))
- access pseudowire (PW)

This example shows how to block unknown-unicast flooding at the bridge domain level:

```
configure
  l2vpn
    bridge-group group1
    bridge-domain domain1
    flooding unknown-unicast disable
  end
```

This example shows how to block unknown-unicast flooding at the bridge port level:

```
configure
  l2vpn
    bridge-group group1
    bridge-domain domain1
    interface GigabitEthernet 0/1/0/1
    flooding unknown-unicast disable
  end
```

This example shows how to block unknown-unicast flooding at the access pseudowire level:

```
configure
  l2vpn
    bridge-group group1
    bridge-domain domain1
    neighbor 10.1.1.1 pw-id 1000
    flooding unknown-unicast disable
  end
```

Disabling MAC Flush: Examples

You can disable the MAC flush at these levels:

- bridge domain
- bridge port (attachment circuit (AC))

- access pseudowire (PW)

The following example shows how to disable the MAC flush at the bridge domain level:

```
configure
  l2vpn
    bridge-group group1
    bridge-domain domain1
    mac
    port-down flush disable
  end
```

The following example shows how to disable the MAC flush at the bridge port level:

```
configure
  l2vpn
    bridge-group group1
    bridge-domain domain1
    interface TenGigE 0/0/0/0
    mac
    port-down flush disable
  end
```

Bridging on IOS XR Trunk Interfaces: Example

This example shows how to configure a as a simple L2 switch.

Important notes:

Create a bridge domain that has four attachment circuits (AC). Each AC is an IOS XR trunk interface (i.e. not a subinterface/EFP).

- This example assumes that the running config is empty, and that all the components are created.
- This example provides all the necessary steps to configure the to perform switching between the interfaces. However, the commands to prepare the interfaces such as no shut, negotiation auto, etc., have been excluded.
- The bridge domain is in a no shut state, immediately after being created.
- Only trunk (i.e. main) interfaces are used in this example.
- The trunk interfaces are capable of handling tagged (i.e. IEEE 802.1Q) or untagged (i.e. no VLAN header) frames.
- The bridge domain learns, floods, and forwards based on MAC address. This functionality works for frames regardless of tag configuration.
- The bridge domain entity spans the entire system. It is not necessary to place all the bridge domain ACs on a single LC. This applies to any bridge domain configuration.
- The show bundle and the show l2vpn bridge-domain commands are used to verify that the router was configured as expected, and that the commands show the status of the new configurations.
- The ACs in this example use interfaces that are in the admin down state.

Configuration Example

```
RP/0/RSP0/CPU0:router#config
RP/0/RSP0/CPU0:router(config)#interface Bundle-ether10
```

```
RP/0/RSP0/CPU0:router(config-if)#l2transport
RP/0/RSP0/CPU0:router(config-if-l2)#interface GigabitEthernet0/2/0/5
RP/0/RSP0/CPU0:router(config-if)#bundle id 10 mode active
RP/0/RSP0/CPU0:router(config-if)#interface GigabitEthernet0/2/0/6
RP/0/RSP0/CPU0:router(config-if)#bundle id 10 mode active
RP/0/RSP0/CPU0:router(config-if)#interface GigabitEthernet0/2/0/0
RP/0/RSP0/CPU0:router(config-if)#l2transport
RP/0/RSP0/CPU0:router(config-if-l2)#interface GigabitEthernet0/2/0/1
RP/0/RSP0/CPU0:router(config-if)#l2transport
RP/0/RSP0/CPU0:router(config-if-l2)#interface TenGigE0/1/0/2
RP/0/RSP0/CPU0:router(config-if)#l2transport
RP/0/RSP0/CPU0:router(config-if-l2)#l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#bridge group examples
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#bridge-domain test-switch
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#interface Bundle-ether10
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#interface GigabitEthernet0/2/0/0
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#interface GigabitEthernet0/2/0/1
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#interface TenGigE0/1/0/2
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#commit
RP/0/RSP0/CPU0:Jul 26 10:48:21.320 EDT: config[65751]: %MGBL-CONFIG-6-DB_COMMIT :
Configuration committed by user 'lab'. Use 'show configuration commit changes 1000000973'
to view the changes.
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#end
RP/0/RSP0/CPU0:Jul 26 10:48:21.342 EDT: config[65751]: %MGBL-SYS-5-CONFIG_I : Configured
from console by lab
RP/0/RSP0/CPU0:router#show bundle Bundle-ether10

Bundle-Ether10
  Status:                                  Down
  Local links <active/standby/configured>:   0 / 0 / 2
  Local bandwidth <effective/available>:     0 (0) kbps
  MAC address (source):                    0024.f71e.22eb (Chassis pool)
  Minimum active links / bandwidth:        1 / 1 kbps
  Maximum active links:                    64
  Wait while timer:                        2000 ms
  LACP:                                    Operational
    Flap suppression timer:                Off
  mLACP:                                   Not configured
  IPv4 BFD:                                Not configured

  Port                  Device           State        Port ID         B/W, kbps
  --------------------  ---------------  -----------  --------------  ----------
  Gi0/2/0/5             Local            Configured   0x8000, 0x0001     1000000
      Link is down
  Gi0/2/0/6             Local            Configured   0x8000, 0x0002     1000000
      Link is down

RP/0/RSP0/CPU0:router#
RP/0/RSP0/CPU0:router#show l2vpn bridge-domain group examples
Bridge group: examples, bridge-domain: test-switch, id: 2000, state: up, ShgId: 0, MSTi: 0
  Aging: 300 s, MAC limit: 4000, Action: none, Notification: syslog
  Filter MAC addresses: 0
  ACs: 4 (1 up), VFIs: 0, PWs: 0 (0 up), PBBs: 0 (0 up)
  List of ACs:
    BE10, state: down, Static MAC addresses: 0
    Gi0/2/0/0, state: up, Static MAC addresses: 0
    Gi0/2/0/1, state: down, Static MAC addresses: 0
    Te0/5/0/1, state: down, Static MAC addresses: 0
  List of VFIs:
RP/0/RSP0/CPU0:router#
```

This table lists the configuration steps (actions) and the corresponding purpose for this example:

SUMMARY STEPS

1. **configure**
2. **interface Bundle-ether10**
3. **l2transport**
4. **interface GigabitEthernet0/2/0/5**
5. **bundle id 10 mode active**
6. **interface GigabitEthernet0/2/0/6**
7. **bundle id 10 mode active**
8. **interface GigabitEthernet0/2/0/0**
9. **l2transport**
10. **interface GigabitEthernet0/2/0/1**
11. **l2transport**
12. **interface TenGigE0/1/0/2**
13. **l2transport**
14. **l2vpn**
15. **bridge group examples**
16. **bridge-domain test-switch**
17. **interface Bundle-ether10**
18. **exit**
19. **interface GigabitEthernet0/2/0/0**
20. **exit**
21. **interface GigabitEthernet0/2/0/1**
22. **exit**
23. **interface TenGigE0/1/0/2**
24. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Enters global configuration mode.

Step 2 **interface Bundle-ether10**

Creates a new bundle trunk interface.

Step 3 **l2transport**

Changes Bundle-ether10 from an L3 interface to an L2 interface.

Step 4 **interface GigabitEthernet0/2/0/5**

Enters interface configuration mode. Changes configuration mode to act on GigabitEthernet0/2/0/5.

Step 5 **bundle id 10 mode active**

Establishes GigabitEthernet0/2/0/5 as a member of Bundle-ether10. The **mode active** keywords specify LACP protocol.

Step 6 **interface GigabitEthernet0/2/0/6**

Enters interface configuration mode. Changes configuration mode to act on GigabitEthernet0/2/0/6.

Step 7 **bundle id 10 mode active**

Establishes GigabitEthernet0/2/0/6 as a member of Bundle-ether10. The **mode active** keywords specify LACP protocol.

Step 8 **interface GigabitEthernet0/2/0/0**

Enters interface configuration mode. Changes configuration mode to act on GigabitEthernet0/2/0/0.

Step 9 **l2transport**

Change GigabitEthernet0/2/0/0 from an L3 interface to an L2 interface.

Step 10 **interface GigabitEthernet0/2/0/1**

Enters interface configuration mode. Changes configuration mode to act on GigabitEthernet0/2/0/1.

Step 11 **l2transport**

Change GigabitEthernet0/2/0/1 from an L3 interface to an L2 interface.

Step 12 **interface TenGigE0/1/0/2**

Enters interface configuration mode. Changes configuration mode to act on TenGigE0/1/0/2.

Step 13 **l2transport**

Changes TenGigE0/1/0/2 from an L3 interface to an L2 interface.

Step 14 **l2vpn**

Enters L2VPN configuration mode.

Step 15 **bridge group examples**

Creates the bridge group **examples**.

Step 16 **bridge-domain test-switch**

Creates the bridge domain **test-switch**, that is a member of bridge group **examples**.

Step 17 **interface Bundle-ether10**

Establishes Bundle-ether10 as an AC of bridge domain test-switch.

Step 18 **exit**

Exits bridge domain AC configuration submode, allowing next AC to be configured.

Step 19 **interface GigabitEthernet0/2/0/0**

Establishes GigabitEthernet0/2/0/0 as an AC of bridge domain **test-switch**.

Step 20 **exit**

Exits bridge domain AC configuration submode, allowing next AC to be configured.

Step 21 **interface GigabitEthernet0/2/0/1**

Establishes GigabitEthernet0/2/0/1 as an AC of bridge domain **test-switch**.

Step 22 **exit**

Exits bridge domain AC configuration submode, allowing next AC to be configured.

Step 23 **interface TenGigE0/1/0/2**

Establishes interface TenGigE0/1/0/2 as an AC of bridge domain **test-switch**.

Step 24 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Bridging on Ethernet Flow Points: Example

This example shows how to configure a to perform Layer 2 switching on traffic that passes through Ethernet Flow Points (EFPs). EFP traffic typically has one or more VLAN headers. Although both IOS XR trunks and IOS XR EFPs can be combined as attachment circuits in bridge domains, this example uses EFPs exclusively.

Important notes:

- An EFP is a Layer 2 subinterface. It is always created under a trunk interface. The trunk interface must exist before the EFP is created.
- In an empty configuration, the bundle interface trunk does not exist, but the physical trunk interfaces are automatically configured. Therefore, only the bundle trunk is created.
- In this example the subinterface number and the VLAN IDs are identical, but this is out of convenience, and is not a necessity. They do not need to be the same values.
- The bridge domain test-efp has three attachment circuits (ACs). All the ACs are EFPs.
- Only frames with a VLAN ID of 999 enter the EFPs. This ensures that all the traffic in this bridge domain has the same VLAN encapsulation.
- The ACs in this example use interfaces that are in the admin down state (**unresolved** state). Bridge domains that use nonexistent interfaces as ACs are legal, and the commit for such configurations does not fail. In this case, the status of the bridge domain shows **unresolved** until you configure the missing interface.

Configuration Example

```
RP/0/RSP1/CPU0:router#configure
RP/0/RSP1/CPU0:router(config)#interface Bundle-ether10
RP/0/RSP1/CPU0:router(config-if)#interface Bundle-ether10.999 l2transport
RP/0/RSP1/CPU0:router(config-subif)#encapsulation dot1q 999
RP/0/RSP1/CPU0:router(config-subif)#interface GigabitEthernet0/6/0/5
RP/0/RSP1/CPU0:router(config-if)#bundle id 10 mode active
RP/0/RSP1/CPU0:router(config-if)#interface GigabitEthernet0/6/0/6
```

```
RP/0/RSP1/CPU0:router(config-if)#bundle id 10 mode active
RP/0/RSP1/CPU0:router(config-if)#interface GigabitEthernet0/6/0/7.999 l2transport
RP/0/RSP1/CPU0:router(config-subif)#encapsulation dot1q 999
RP/0/RSP1/CPU0:router(config-subif)#interface TenGigE0/1/0/2.999 l2transport
RP/0/RSP1/CPU0:router(config-subif)#encapsulation dot1q 999
RP/0/RSP1/CPU0:router(config-subif)#l2vpn
RP/0/RSP1/CPU0:router(config-l2vpn)#bridge group examples
RP/0/RSP1/CPU0:router(config-l2vpn-bg)#bridge-domain test-efp
RP/0/RSP1/CPU0:router(config-l2vpn-bg-bd)#interface Bundle-ether10.999
RP/0/RSP1/CPU0:router(config-l2vpn-bg-bd-ac)#exit
RP/0/RSP1/CPU0:router(config-l2vpn-bg-bd)#interface GigabitEthernet0/6/0/7.999
RP/0/RSP1/CPU0:router(config-l2vpn-bg-bd-ac)#exit
RP/0/RSP1/CPU0:router(config-l2vpn-bg-bd)#interface TenGigE0/1/0/2.999
RP/0/RSP1/CPU0:router(config-l2vpn-bg-bd-ac)#commit
RP/0/RSP1/CPU0:router(config-l2vpn-bg-bd-ac)#end
RP/0/RSP1/CPU0:router#
RP/0/RSP1/CPU0:router#show l2vpn bridge group examples
Fri Jul 23 21:56:34.473 UTC Bridge group: examples, bridge-domain: test-efp, id: 0, state:
 up, ShgId: 0, MSTi: 0
Aging: 300 s, MAC limit: 4000, Action: none, Notification: syslog
  Filter MAC addresses: 0
  ACs: 3 (0 up), VFIs: 0, PWs: 0 (0 up), PBBs: 0 (0 up)
  List of ACs:
    BE10.999, state: down, Static MAC addresses: 0
    Gi0/6/0/7.999, state: unresolved, Static MAC addresses: 0
    Te0/1/0/2.999, state: down, Static MAC addresses: 0
  List of VFIs:
RP/0/RSP1/CPU0:router#
```

This table lists the configuration steps (actions) and the corresponding purpose for this example:

SUMMARY STEPS

1. **configure**
2. **interface Bundle-ether10**
3. **interface Bundle-ether10.999 l2transport**
4. **encapsulation dot1q 999**
5. **interface GigabitEthernet0/6/0/5**
6. **bundle id 10 mode active**
7. **interface GigabitEthernet0/6/0/6**
8. **bundle id 10 mode active**
9. **interface GigabitEthernet0/6/0/7.999 l2transport**
10. **encapsulation dot1q 999**
11. **interface TenGigE0/1/0/2.999 l2transport**
12. **encapsulation dot1q 999**
13. **l2vpn**
14. **bridge group examples**
15. **bridge-domain test-efp**
16. **interface Bundle-ether10.999**
17. **exit**
18. **interface GigabitEthernet0/6/0/7.999**
19. **exit**
20. **interface TenGigE0/1/0/2.999**
21. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Enters global configuration mode.

Step 2 **interface Bundle-ether10**

Creates a new bundle trunk interface.

Step 3 **interface Bundle-ether10.999 l2transport**

Creates an EFP under the new bundle trunk.

Step 4 **encapsulation dot1q 999**

Assigns VLAN ID of 999 to this EFP.

Step 5 **interface GigabitEthernet0/6/0/5**

Enters interface configuration mode. Changes configuration mode to act on GigabitEthernet0/6/0/5.

Step 6 **bundle id 10 mode active**

Establishes GigabitEthernet0/6/0/5 as a member of Bundle-ether10. The **mode active** keywords specify LACP protocol.

Step 7 **interface GigabitEthernet0/6/0/6**

Enters interface configuration mode. Changes configuration mode to act on GigabitEthernet0/6/0/6.

Step 8 **bundle id 10 mode active**

Establishes GigabitEthernet0/6/0/6 as a member of Bundle-ether10. The **mode active** keywords specify LACP protocol.

Step 9 **interface GigabitEthernet0/6/0/7.999 l2transport**

Creates an EFP under GigabitEthernet0/6/0/7.

Step 10 **encapsulation dot1q 999**

Assigns VLAN ID of 999 to this EFP.

Step 11 **interface TenGigE0/1/0/2.999 l2transport**

Creates an EFP under TenGigE0/1/0/2.

Step 12 **encapsulation dot1q 999**

Assigns VLAN ID of 999 to this EFP.

Step 13 **l2vpn**

Enters L2VPN configuration mode.

Step 14 **bridge group examples**

Creates the bridge group named **examples**.

Step 15 **bridge-domain test-efp**

Creates the bridge domain named **test-efp**, that is a member of bridge group **examples**.

Step 16 **interface Bundle-ether10.999**

Establishes Bundle-ether10.999 as an AC of the bridge domain named **test-efp**.

Step 17 **exit**

Exits bridge domain AC configuration submode, allowing next AC to be configured.

Step 18 **interface GigabitEthernet0/6/0/7.999**

Establishes GigabitEthernet0/6/0/7.999 as an AC of the bridge domain named **test-efp**.

Step 19 **exit**

Exits bridge domain AC configuration submode, allowing next AC to be configured.

Step 20 **interface TenGigE0/1/0/2.999**

Establishes interface TenGigE0/1/0/2.999 as an AC of bridge domain named **test-efp**.

Step 21 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

Changing the Flood Optimization Mode

Perform this task to change the flood optimization mode under the bridge domain:

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **flood mode convergence-optimized**
6. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# bridge group csco
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#
```

Creates a bridge group so that it can contain bridge domains and then assigns network interfaces to the bridge domain.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg)# bridge-domain abc
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#
```

Establishes a bridge domain and enters l2vpn bridge group bridge domain configuration mode.

Step 5 **flood mode convergence-optimized**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# flood mode convergence-optimized
```

Changes the default flood optimization mode from Bandwidth Optimization Mode to Convergence Mode.

When you configure **flood mode convergence-optimized**, you must remove and reconfigure the bridge domain when you add, modify, or remove the pseudowire configuration of a specific bridge domain.

Step 6 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.

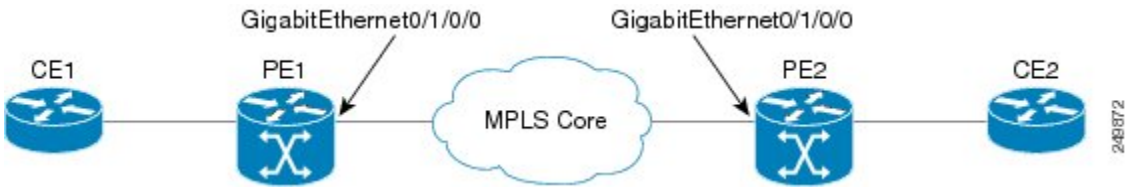
Configuring VPLS with BGP Autodiscovery and Signaling: Example

This section contains these configuration examples for configuring the BGP autodiscovery and signaling feature:

LDP and BGP Configuration

The following figure illustrates an example of LDP and BGP configuration.

Figure 19: LDP and BGP Configuration



Configuration at PE1:

```
interface Loopback0
 ipv4 address 10.0.0.100 255.0.0.0
!
interface Loopback1
 ipv4 address 10.0.0.1 255.0.0.0
!
mpls ldp
 router-id 10.0.0.10
 interface GigabitEthernt0/1/0/0
!
router bgp 120
 address-family l2vpn vpls-vpws
!
 neighbor 172.16.0.1
 remote-as 120
 update-source Loopback1
 address-family l2vpn vpls-vpws
 signaling bgp disable
```

Configuration at PE2:

```
interface Loopback0
 ipv4 address 172.16.0.10 255.255.255.255
!
interface Loopback1
 ipv4 address 172.16.0.1 255.255.255.255
!
mpls ldp
 router-id 172.16.0.100
 interface GigabitEthernt0/1/0/0
!
router bgp 120
 address-family l2vpn vpls-vpws
!
 neighbor 10.0.0.11
 remote-as 120
 update-source Loopback1
 address-family l2vpn vpls-vpws
```

Minimum L2VPN Configuration for BGP Autodiscovery with BGP Signaling

This example illustrates the minimum L2VPN configuration required for BGP Autodiscovery with BGP Signaling, where any parameter that has a default value is not configured.

```
(config)# l2vpn
(config-l2vpn)# bridge group {bridge group name}
(config-l2vpn-bg)# bridge-domain {bridge domain name}
(config-l2vpn-bg-bd)# vfi {vfi name}
(config-l2vpn-bg-bd-vfi)# autodiscovery bgp
(config-l2vpn-bg-bd-vfi-ad)# vpn-id 10
(config-l2vpn-bg-bd-vfi-ad)# rd auto
(config-l2vpn-bg-bd-vfi-ad)# route-target 10.0.0.1:100
(config-l2vpn-bg-bd-vfi-ad-sig)# signaling-protocol bgp
(config-l2vpn-bg-bd-vfi-ad-sig)# ve-id 1
(config-l2vpn-bg-bd-vfi-ad-sig)# commit
```

VPLS with BGP Autodiscovery and BGP Signaling

The following figure illustrates an example of configuring VPLS with BGP autodiscovery (AD) and BGP Signaling.

Figure 20: VPLS with BGP autodiscovery and BGP signaling

Configuration at PE1:

```
l2vpn
  bridge group gr1
   bridge-domain bd1
    interface GigabitEthernet0/1/0/1.1
    vfi vf1
    ! AD independent VFI attributes
    vpn-id 100
    ! Auto-discovery attributes
    autodiscovery bgp
    rd auto
    route-target 2.2.2.2:100
    ! Signaling attributes
    signaling-protocol bgp
    ve-id 3
```

Configuration at PE2:

```
l2vpn
  bridge group gr1
   bridge-domain bd1
    interface GigabitEthernet0/1/0/2.1
    vfi vf1
    ! AD independent VFI attributes
    vpn-id 100
    ! Auto-discovery attributes
    autodiscovery bgp
    rd auto
    route-target 2.2.2.2:100
    ! Signaling attributes
    signaling-protocol bgp
    ve-id 5
```

This is an example of NLRI for VPLS with BGP AD and signaling:

Discovery Attributes

NLRI sent at PE1:

```
Length = 19
Router Distinguisher = 3.3.3.3:32770
VE ID = 3
VE Block Offset = 1
VE Block Size = 10
Label Base = 16015
```

NLRI sent at PE2:

```
Length = 19
Router Distinguisher = 1.1.1.1:32775
VE ID = 5
VE Block Offset = 1
VE Block Size = 10
Label Base = 16120
```

Minimum Configuration for BGP Autodiscovery with LDP Signaling

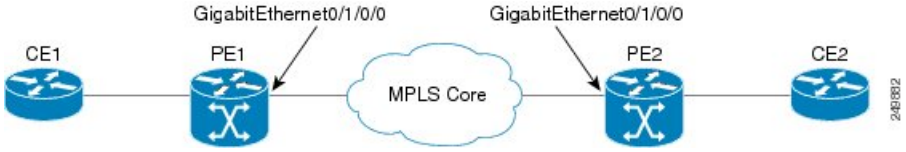
This example illustrates the minimum L2VPN configuration required for BGP Autodiscovery with LDP Signaling, where any parameter that has a default value is not configured.

```
(config)# l2vpn
(config-l2vpn)# bridge group {bridge group name}
(config-l2vpn-bg)# bridge-domain {bridge domain name}
(config-l2vpn-bg-bd)# vfi {vfi name}
(config-l2vpn-bg-bd-vfi)# autodiscovery bgp
(config-l2vpn-bg-bd-vfi-ad)# vpn-id 10
(config-l2vpn-bg-bd-vfi-ad)# rd auto
(config-l2vpn-bg-bd-vfi-ad)# route-target 1.1.1.1:100
(config-l2vpn-bg-bd-vfi-ad)# commit
```

VPLS with BGP Autodiscovery and LDP Signaling

The following figure illustrates an example of configuring VPLS with BGP autodiscovery (AD) and LDP Signaling.

Figure 21: VPLS with BGP autodiscovery and LDP signaling



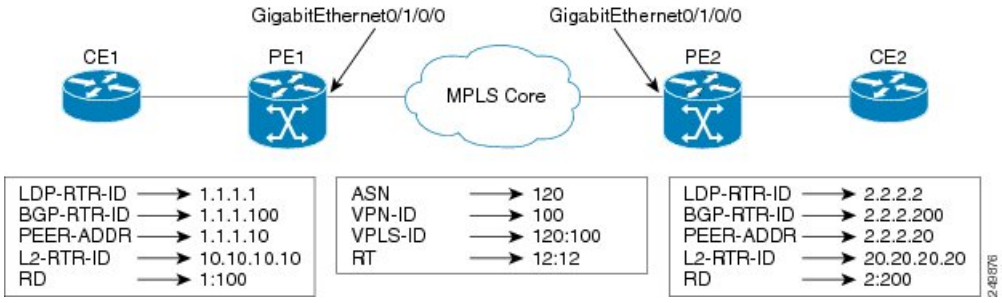
Configuration at PE1:

```
l2vpn
  router-id 10.10.10.10
  bridge group bg1
   bridge-domain bd1
    vfi vf1
    vpn-id 100
    autodiscovery bgp
    rd 1:100
    router-target 12:12
```

Configuration at PE2:

```
l2vpn
  router-id 20.20.20.20
  bridge group bg1
   bridge-domain bd1
    vfi vf1
     vpn-id 100
     autodiscovery bgp
      rd 2:200
      router-target 12:12
      signaling-protocol ldp
       vpls-id 120:100
```

Discovery and Signaling Attributes



Configuration at PE1:

```
LDP Router ID - 10.0.0.1
BGP Router ID - 10.0.0.100
Peer Address -  10.0.0.10
L2VPN Router ID - 10.10.10.10
Route Distinguisher - 1:100
```

Common Configuration between PE1 and PE2:

```
ASN - 120
VPN ID - 100
VPLS ID - 120:100
Route Target - 12:12
```

Configuration at PE2:

```
LDP Router ID - 172.16.0.1
BGP Router ID - 172.16.0.100
Peer Address -  172.16.0.10
L2VPN Router ID - 192.168.0.1
Route Distinguisher - 2:200
```

Discovery Attributes

NLRI sent at PE1:

```
Source Address - 10.0.0.10
Destination Address - 172.16.0.10
Length - 14
Route Distinguisher - 1:100
L2VPN Router ID - 10.10.10.10
VPLS ID - 120:100
Route Target - 12:12
```

NLRI sent at PE2:

```
Source Address - 172.16.0.10
Destination Address - 10.0.0.10
Length - 14
Route Distinguisher - 2:200
L2VPN Router ID - 192.168.0.1
VPLS ID - 120:100
Route Target - 12:12
```

Enabling VC type 4 for BGP Autodiscovery

This example shows how to configure virtual connection type 4 in VPLS with BGP autodiscovery:

```
l2vpn
bridge group bg1
  bridge-domain bd1
   transport-mode vlan passthrough
   interface GigabitEthernet0/0/0/1.1
   !
   neighbor 172.16.0.1 pw-id 1
   !
   vfi vf1
    vpn-id 100
    autodiscovery bgp
     rd auto
     route-target 1:1
     signalining-protocol ldp
    !
   !
  !
!
```

VPLS with both BGP Autodiscovery and Manual Provisioning of VPLS Peers

This example shows VPLS configuration with BGP autodiscovery as well as manual provisioning of VPLS peers that are not participating in the BGP autodiscovery process.

```
!
l2vpn
 bridge group bg1
  bridge-domain bd1
   !
   vfi vfi1
    vpn-id 500
    autodiscovery bgp
     rd auto
     route-target 65533:12345678
     signaling-protocol ldp
      vpls-id 65533:12345678
    ! Manually provisioned peers
    neighbor 10.10.10.2 pw-id 102
!
```

Configuring Dynamic ARP Inspection: Example

This example shows how to configure basic dynamic ARP inspection under a bridge domain:

```
config
l2vpn
 bridge group MyGroup
 bridge-domain MyDomain
 dynamic-arp-inspection logging
```

This example shows how to configure basic dynamic ARP inspection under a bridge port:

```
config
l2vpn
 bridge group MyGroup
 bridge-domain MyDomain
  interface gigabitEthernet 0/1/0/0.1
 dynamic-arp-inspection logging
```

This example shows how to configure optional dynamic ARP inspection under a bridge domain:

```
l2vpn
  bridge group SECURE
    bridge-domain SECURE-DAI
      dynamic-arp-inspection
        logging
        address-validation
          src-mac
          dst-mac
           ipv4
```

This example shows how to configure optional dynamic ARP inspection under a bridge port:

```
l2vpn
  bridge group SECURE
    bridge-domain SECURE-DAI
      interface GigabitEthernet0/0/0/1.10
        dynamic-arp-inspection
          logging
          address-validation
           src-mac
           dst-mac
           ipv4
```

This example shows the output of the **show l2vpn bridge-domain** *bd-name* SECURE-DAI **detail** command:

```
#show l2vpn bridge-domain bd-name SECURE-DAI detail
Bridge group: SECURE, bridge-domain: SECURE-DAI, id: 2, state: up,
…
```

```
Dynamic ARP Inspection: enabled, Logging: enabled
Dynamic ARP Inspection Address Validation:
   IPv4 verification: enabled
   Source MAC verification: enabled
    Destination MAC verification: enabled
…
List of ACs:
 AC: GigabitEthernet0/0/0/1.10, state is up
…
    Dynamic ARP Inspection: enabled, Logging: enabled
    Dynamic ARP Inspection Address Validation:
        IPv4 verification: enabled
        Source MAC verification: enabled
        Destination MAC verification: enabled
        IP Source Guard: enabled, Logging: enabled

…
   Dynamic ARP inspection drop counters:
      packets: 1000, bytes: 64000
```

This example shows the output of the **show l2vpn forwarding interface** *interface-name* **detail location** *location-name* command:

```
#show l2vpn forwarding interface g0/0/0/1.10 det location 0/0/CPU0
Local interface: GigabitEthernet0/0/0/1.10, Xconnect id: 0x40001, Status: up

…
    Dynamic ARP Inspection: enabled, Logging: enabled
    Dynamic ARP Inspection Address Validation:
        IPv4 verification: enabled
        Source MAC verification: enabled
        Destination MAC verification: enabled
        IP Source Guard: enabled, Logging: enabled
```

This example shows the logging display:

```
LC/0/0/CPU0:Jun 16 13:28:28.697 : l2fib[188]: %L2-L2FIB-5-SECURITY_DAI_VIOLATION_AC : Dynamic
 ARP inspection in AC GigabitEthernet0_0_0_7.1000 detected violated packet - source MAC:
0000.0000.0065, destination MAC: 0000.0040.0000, sender MAC: 0000.0000.0064, target MAC:
0000.0000.0000, sender IP: 5.6.6.6, target IP: 130.10.3.2

LC/0/5/CPU0:Jun 16 13:28:38.716 : l2fib[188]: %L2-L2FIB-5-SECURITY_DAI_VIOLATION_AC : Dynamic
 ARP inspection in AC Bundle-Ether100.103 detected violated packet - source MAC:
0000.0000.0067, destination MAC: 0000.2300.0000, sender MAC: 0000.7800.0034, target MAC:
0000.0000.0000, sender IP: 130.2.5.1, target IP: 50.5.1.25
```

Configuring IP Source Guard: Example

This example shows how to configure basic IP source guard under a bridge domain:

```
config
l2vpn
 bridge group MyGroup
 bridge-domain MyDomain
 ip-source-guard logging
```

This example shows how to configure basic IP source guard under a bridge port:

```
config
l2vpn
 bridge group MyGroup
 bridge-domain MyDomain
```

```
  interface gigabitEthernet 0/1/0/0.1
 ip-source-guard  logging
```

This example shows how to configure optional IP source guard under a bridge domain:

```
l2vpn
  bridge group SECURE
    bridge-domain SECURE-IPSG
       ip-source-guard
         logging
```

This example shows how to configure optional IP source guard under a bridge port:

```
l2vpn
  bridge group SECURE
    bridge-domain SECURE-IPSG
      interface GigabitEthernet0/0/0/1.10
        ip-source-guard
          logging
```

This example shows the output of the **show l2vpn bridge-domain** *bd-name ipsg-name* **detail** command:

```
# show l2vpn bridge-domain bd-name SECURE-IPSG detail
Bridge group: SECURE, bridge-domain: SECURE-IPSG, id: 2, state: up,
…
  IP Source Guard: enabled, Logging: enabled
…
List of ACs:
 AC: GigabitEthernet0/0/0/1.10, state is up
…

   IP Source Guard: enabled, Logging: enabled
…
   IP source guard drop counters:
      packets: 1000, bytes: 64000
```

This example shows the output of the **show l2vpn forwarding interface** *interface-name* **detail location** *location-name* command:

```
# show l2vpn forwarding interface g0/0/0/1.10 detail location 0/0/CPU0
Local interface: GigabitEthernet0/0/0/1.10, Xconnect id: 0x40001, Status: up

…
    IP Source Guard: enabled, Logging: enabled
```

This example shows the logging display:

```
LC/0/0/CPU0:Jun 16 13:32:25.334 : l2fib[188]: %L2-L2FIB-5-SECURITY_IPSG_VIOLATION_AC : IP
source guard in AC  GigabitEthernet0_0_0_7.1001 detected violated packet - source MAC:
0000.0000.0200, destination MAC: 0000.0003.0000, source IP: 130.0.0.1, destination IP:
125.34.2.5



LC/0/5/CPU0:Jun 16 13:33:25.530 : l2fib[188]: %L2-L2FIB-5-SECURITY_IPSG_VIOLATION_AC : IP
source guard in AC Bundle-Ether100.100  detected violated packet - source MAC: 0000.0000.0064,
 destination MAC: 0000.0040.0000, source IP: 14.5.1.3, destination IP: 45.1.1.10
```

Configuring G.8032 Ethernet Ring Protection: Example

This sample configuration illustrates the elements that a complete G.8032 configuration includes:

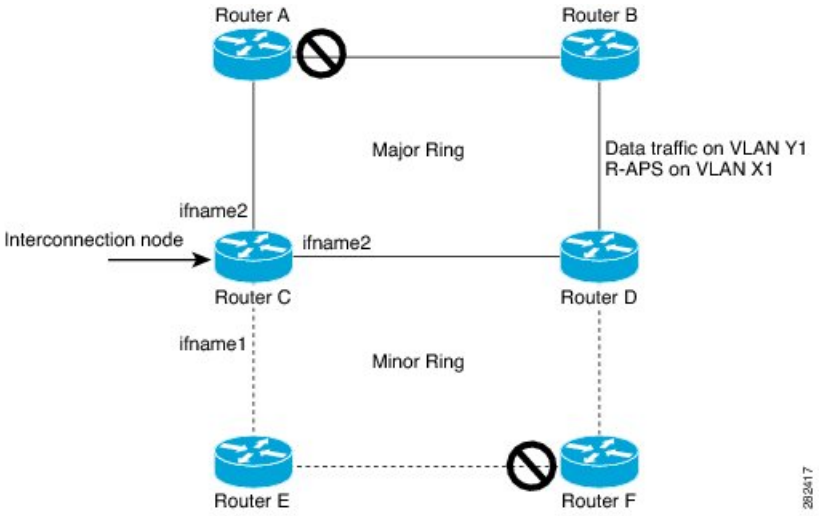
```
# Configure the ERP profile characteristics if ERP instance behaviors are non-default.
ethernet ring g8032 profile ERP-profile
  timer wtr 60
  timer guard 100
  timer hold-off 1
  non-revertive

# Configure CFM MEPs and configure to monitor the ring links.
ethernet cfm
  domain domain1
    service link1 down-meps
   continuity-check interval 100ms
      efd
   mep crosscheck
  mep-id 2
  domain domain2
    service link2 down-meps
   continuity-check interval 100ms
      efd protection-switching
   mep crosscheck
  mep id 2

Interface Gig 0/0/0/0
  ethernet cfm mep domain domain1 service link1 mep-id 1
Interface Gig 1/1/0/0
  ethernet cfm mep domain domain2 service link2 mep-id 1

# Configure the ERP instance under L2VPN
l2vpn
  ethernet ring g8032 RingA
    port0 interface g0/0/0/0
    port1 interface g0/1/0/0
    instance 1
      description BD2-ring
      profile ERP-profile
      rpl port0 owner
      vlan-ids 10-100
      aps channel
        level 3
        port0 interface g0/0/0/0.1
        port1 interface g1/1/0/0.1

# Set up the bridge domains
bridge group ABC
    bridge-domain BD2
      interface Gig 0/0/0/0.2
      interface Gig 0/1/0/0.2
      interface Gig 0/2/0/0.2

    bridge-domain BD2-APS
      interface Gig 0/0/0/0.1
      interface Gig 1/1/0/0.1

# EFPs configuration
interface Gig 0/0/0/0.1 l2transport
  encapsulation dot1q 5

interface Gig 1/1/0/0.1 l2transport
  encapsulation dot1q 5
```

```
interface g 0/0/0/0.2 l2transport
  encapsulation dot1q 10-100

interface g 0/1/0/0.2 l2transport
  encapsulation dot1q 10-100

interface g 0/2/0/0.2 l2transport
  encapsulation dot1q 10-100
```

Configuring Interconnection Node: Example

This example shows you how to configure an interconnection node. The following figure illustrates an open ring scenario.

Figure 22: Open Ring Scenario - interconnection node



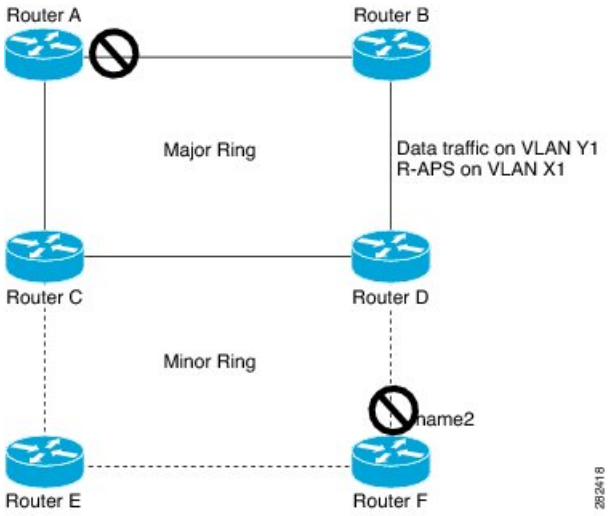
The minimum configuration required for configuring G.8032 at Router C (Open ring – Router C):

```
interface <ifname1.1> l2transport
 encapsulation dot1q X1
interface <ifname1.10> l2transport
 encapsulation dot1q Y1
interface <ifname2.10> l2transport
 encapsulation dot1q Y1
interface <ifname3.10> l2transport
 encapsulation dot1q Y1
l2vpn
ethernet ring g8032 <ring-name>
      port0 interface <main port ifname1>
      port1 interface none #? This router is connected to an interconnection node
      open-ring #? Mandatory when a router is part of an open-ring
      instance <1-2>
         inclusion-list vlan-ids  X1-Y1
         aps-channel
           Port0 interface <ifname1.1>
           Port1 none #? This router is connected to an interconnection node
 bridge group bg1
    bridge-domain bd-aps#? APS-channel has its own bridge domain
       <ifname1.1> #? There is only one APS-channel at the interconnection node
    bridge-domain bd-traffic #? Data traffic has its own bridge domain
       <ifname1.10>
       <ifname2.10>
       <ifname3.10>
```

Configuring the Node of an Open Ring: Example

This example shows you how to configure the node part of an open ring. The following figure illustrates an open ring scenario.

Figure 23: Open Ring Scenario



The minimum configuration required for configuring G.8032 at the node of the open ring (node part of the open ring at router F):

```
interface <ifname1.1> l2transport
 encapsulation dot1q X1
interface <ifname2.1> l2transport
 encapsulation dot1q X1
interface <ifname1.10> l2transport
 encapsulation dot1q Y1
interface <ifname2.10> l2transport
 encapsulation dot1q Y1
l2vpn
   ethernet ring g8032 <ring-name>
      port0 interface <main port ifname1>
      port1 interface <main port ifname2>
      open-ring #? Mandatory when a router is part of an open-ring
      instance <1-2>
         inclusion-list vlan-ids  X1-Y1
      rpl port1 owner #? This node is RPL owner and <main port ifname2> is blocked
         aps-channel
           port0 interface <ifname1.1>
           port1 interface <ifname2.1>
 bridge group bg1
    bridge-domain bd-aps#? APS-channel has its own bridge domain
       <ifname1.1>
       <ifname2.1>
    bridge-domain bd-traffic #? Data traffic has its own bridge domain
       <ifname1.10>
       <ifname2.10>
```

Configuring Flow Aware Transport Pseudowire: Example

This sample configuration shows how to enable load balancing with FAT PW for VPWS.

```
l2vpn
pw-class class1
    encapsulation mpls
        load-balancing flow-label transmit
    !
 !
pw-class class2
    encapsulation mpls
        load-balancing flow-label both
    !

xconnect group group1
    p2p p1
        interface TenGigE 0/0/0/0.1
        neighbor 1.1.1.1 pw-id 1
            pw-class class1
        !
    !
!
```

This sample configuration shows how to enable load balancing with FAT PW for VPLS.

Note For VPLS, the configuration at the bridge-domain level is applied to all PWs (access and VFI PWs). Pseudowire classes are defined to override the configuration for manual PWs.

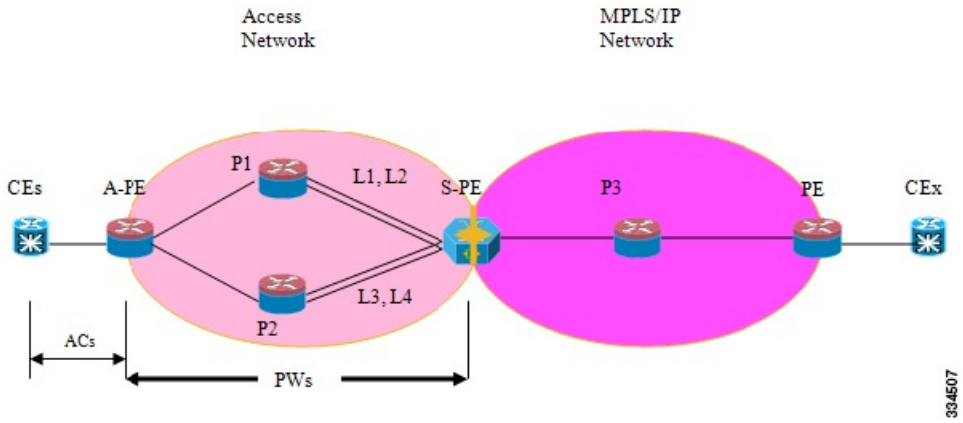
```
l2vpn
pw-class class1
 encapsulation mpls
 load-balancing flow-label both

bridge group group1
    bridge-domain domain1
        vfi vfi2-auto-bgp
                autodiscovery bgp
                   signaling-protocol bgp
                       load-balancing flow-label both static
                !
            !
        !
    !
    bridge-domain domain2
        vfi vfi2-auto-ldp
                autodiscovery bgp
                   signaling-protocol ldp
                       load-balancing flow-label both static
                !
            !
        !
    !
!
```

Configuring Pseudowire Headend: Example

This example shows how to configure pseudowire headend.

Consider the topology in the following figure.

Figure 24: Pseudowire Headend Example



There are multiple CEs connected to A-PE (each CE is connected by one link). There are two P routers between A-PE an S-PE in the access network. The S-PE is connected using two links to P1. These links L1 and L2 (on two different line cards on P1 and S-PE), e.g. Gig0/1/0/0 and Gig0/2/0/0 respectively.

The S-PE is connected by two links to P2, links L3 and L4 (on two different line cards on P2 and S-PE), e.g. Gig0/1/0/1 and Gig0/2/0/1 respectively. For each CE-APE link, a xconnect (AC-PW) is configured on the A-PE. A-PE uses router-id 100.100.100.100 for routing and PW signaling. Two router-ids on S-PE used for PW signaling, e.g. 111.111.111.111 and 112.112.112.112 (for rx pin-down), 110.110.110.110 is the router-id for routing.

CE Configuration

Consider two CEs that are connected through Ge0/3/0/0 (CE1 and A-PE) and Ge0/3/0/1 (CE2 and A-PE).

CE1

```
interface Gig0/3/0/0
 ipv4 address 10.0.0.1/8
router static
 address-family ipv4 unicast
  110.110.110.110 Gig0/3/0/0
  A.B.C.D/N 110.110.110.110
```

CE2

```
interface Gig0/3/0/1
 ipv4 address 10.1.2.1/24
router static
 address-family ipv4 unicast
  110.110.110.110 Gig0/3/0/1
  A.B.C.D/N 110.110.110.110
```

A-PE Configuration

At A-PE we have 1 xconnect for each CE connection. Here we give the configuration for the 2 CE connections above: both connections are L2 links which are in xconnects. Each xconnect has a PW destined to S-PE but we use a different neighbor address depending of where we want to pin-down the PW: [L1, L4] or [L2, L3]

```
interface Gig0/3/0/0
 l2transport
interface Gig0/3/0/1
 l2transport

l2vpn
 xconnect group pwhe
  p2p pwhe_spe_1
   interface Gig0/3/0/0
   neighbor 111.111.111.111 pw-id 1
  p2p pwhe_spe_2
   interface Gig0/3/0/1
   neighbor 112.112.112.112 pw-id 2
```

P Router Configuration

We need static routes on P routers for rx pindown on S-PE, i.e. to force PWs destined to a specific address to be transported over certain links.

P1

```
router static
 address-family ipv4 unicast
  111.111.111.111 Gig0/1/0/0
  112.112.112.112 Gig0/2/0/0
```

P2

```
router static
 address-family ipv4 unicast
  111.111.111.111 Gig0/2/0/1
  112.112.112.112 Gig0/1/0/1
```

S-PE Configuration

At S-PE we have 2 PW-HE interfaces (1 for each PW) and each uses a different interface list for tx pin-down (has to match the static config at P routers for rx pin-down). Each PW-HE has its PW going to A-PE (pw-id has to match what's at A-PE).

```
generic-interface-list il1
 interface gig0/1/0/0
 interface gig0/2/0/0
generic-interface-list il2
 interface gig0/1/0/1
 interface gig0/2/0/1

interface pw-ether1
 ipv4 address 10.1.1.2/24
 attach generic-interface-list il1
interface pw-ether2
 ipv4 address 10.1.2.2/24
 attach generic-interface-list il2

l2vpn
 xconnect group pwhe
  p2p pwhe1
   interface pw-ether1
```

```
   neighbor 100.100.100.100 pw-id 1
  p2p pwhe2
   interface pw-ether2
   neighbor 100.100.100.100 pw-id 2
```

Configuring L2VPN over GRE: Example

Configure the PW core interfaces under IGP and ensure that the loopback is reachable. Configure the tunnel source such that the tunnel is the current loopback as well as destination of the peer PE loopback. Now, configure the GRE tunnel in IGP (OSPF or ISIS), and also under **mpls ldp** and ensure that the LDP neighbor is established between the PEs for the PW. This ensures that the PW is Up through the tunnel.

Configuration on PE1:

```
router ospf 1
router-id 1.1.1.1
 area 0
  interface Loopback0
  interface TenGigE0/0/0/1
router ospf 2
 router-id 200.200.200.200
 area 0
  interface Loopback1000
   interface tunnel-ip1
mpls ldp
 router-id 200.200.200.200
 interface tunnel-ip1
```

Configuration on PE2:

```
router ospf 1
 router-id 3.3.3.3
 area 0
  interface Loopback0
interface TenGigE0/2/0/3
router ospf 2
 router-id 201.201.201.201
 area 0
  interface Loopback1000
   interface tunnel-ip1
!
mpls ldp
 router-id 201.201.201.201
 interface tunnel-ip1
```

Configuring a GRE Tunnel as the Preferred Path for Pseudowire: Example

This example shows how to configure a GRE tunnel as the preferred path for a pseudowire.

```
l2vpn
 pw-class gre
  encapsulation mpls
  preferred-path interface tunnel-ip 1 fallback disable
```

Configuring a GRE Tunnel as Preferred Path for Pseudowire

Perform this task to configure a GRE tunnel as the preferred path for pseudowires.

SUMMARY STEPS

1. **configure**

2. **l2vpn**
3. **pw-class** { *name* }
4. **encapsulation mpls**
5. **preferred-path** { **interface** } { **tunnel-ip** *value* | **tunnel-te** *value* | **tunnel-tp** *value* } [**fallback disable**]
6. Use the **commit** or **end** command.

DETAILED STEPS

Step 1 **configure**

Example:

```
RP/0/RSP0/CPU0:router# configure
```

Enters the Global Configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RSP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **pw-class** { *name* }

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn)# pw-class gre
```

Configures the pseudowire class name.

Step 4 **encapsulation mpls**

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-pwc)# encapsulation mpls
```

Configures the pseudowire encapsulation to MPLS.

Step 5 **preferred-path** { **interface** } { **tunnel-ip** *value* | **tunnel-te** *value* | **tunnel-tp** *value* } [**fallback disable**]

Example:

```
RP/0/RSP0/CPU0:router(config-l2vpn-pwc-encap-
mpls)# preferred-path interface tunnel-ip 1 fallback disable
```

Configures preferred path tunnel settings. If the fallback disable configuration is used and once the TE/TP tunnel is configured as the preferred path goes down, the corresponding pseudowire can also go down.

Note Ensure that fallback is supported.

Step 6 Use the **commit** or **end** command.

commit - Saves the configuration changes and remains within the configuration session.

end - Prompts user to take one of these actions:

- **Yes** - Saves configuration changes and exits the configuration session.
- **No** - Exits the configuration session without committing the configuration changes.
- **Cancel** - Remains in the configuration mode, without committing the configuration changes.