Preface

The *Cisco ASR 9000 Series Aggregation Services Router L2VPN and Ethernet Services Configuration Guide* preface contains these sections:

Changes to This Document

Table 1 lists the technical changes made to this document since it was first printed.

Table 1 Changes to This Document

Revision	Date	Change Summary
OL-26116-02	June 2012	Documentation was added for the Flow Aware Transport (FAT) Pseudowire feature.
OL-26116-01	December 2011	Intial release of this document.

Obtaining Documentation and Submitting a Service Request

For information on obtaining documentation, submitting a service request, and gathering additional information, see the monthly *What's New in Cisco Product Documentation*, which also lists all new and revised Cisco technical documentation, at:

http://www.cisco.com/en/US/docs/general/whatsnew/whatsnew.html

Subscribe to the *What's New in Cisco Product Documentation* as a Really Simple Syndication (RSS) feed and set content to be delivered directly to your desktop using a reader application. The RSS feeds are a free service and Cisco currently supports RSS version 2.0.

The Cisco ASR 9000 Series Routers Carrier Ethernet Model

This module introduces you to Layer 2 (L2) features and standards. This module also describes how to configure L2VPN features on the Cisco ASR 9000 Series Aggregation Services Routers supporting Cisco IOS XR software.

The distributed Gigabit Ethernet and 10-Gigabit Ethernet architecture and features deliver network scalability and performance, while enabling service providers to offer high-density, high-bandwidth networking solutions designed to interconnect the router with other systems in POPs, including core and edge routers and L2 and Layer 3 (L3) switches.

Note This module does not include configuration information for Management Ethernet interfaces. To set up a Management Ethernet interface and enable Telnet servers, see the *Cisco ASR 9000 Series Aggregation Services Routers Getting Started Guide*. To configure a Management Ethernet interface for routing or to modify the configuration of a Management Ethernet interface, see the *Advanced Configuration and Modification of the Management Ethernet Interface on the Cisco ASR 9000 Series Router* module.

Feature History for Configuring Ethernet Interfaces on the Cisco ASR 9000 Series Routers

Release	Modification
Release 3.7.2	This feature was introduced on the Cisco ASR 9000 Series Routers.
Release 4.1.1	Scalability of EFPs on bundle interfaces was introduced.

Contents

Prerequisites for Configuring Layer 2 Ethernet Interfaces

Before configuring Ethernet interfaces, 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.
- Confirm that at least one of these line cards is installed on the Cisco ASR 9000 Series Routers:
  - 4-port 10-Gigabit Ethernet (4 x 10 GE) line card
  - 8-port 10-Gigabit Ethernet (4 x 10 GE) line card
  - 40-port 1-Gigabit Ethernet line card
- You know the interface IP address.
- You know how to apply the specify the generalized interface name with the generalized notation *rack/slot/module/port*.

Cisco ASR 9000 Series Routers Layer 2 Theory and Standards Adherence

To configure Ethernet interfaces, you must understand these concepts:

Ethernet Technology Overview

Ethernet is defined by the IEEE 802.3 international standard. It enables the connection of up to 1024 nodes over coaxial, twisted-pair, or fiber-optic cable.

The Cisco ASR 9000 Series Routers supports Gigabit Ethernet (1000 Mbps) and 10-Gigabit Ethernet (10 Gbps) interfaces.

Carrier Ethernet Services

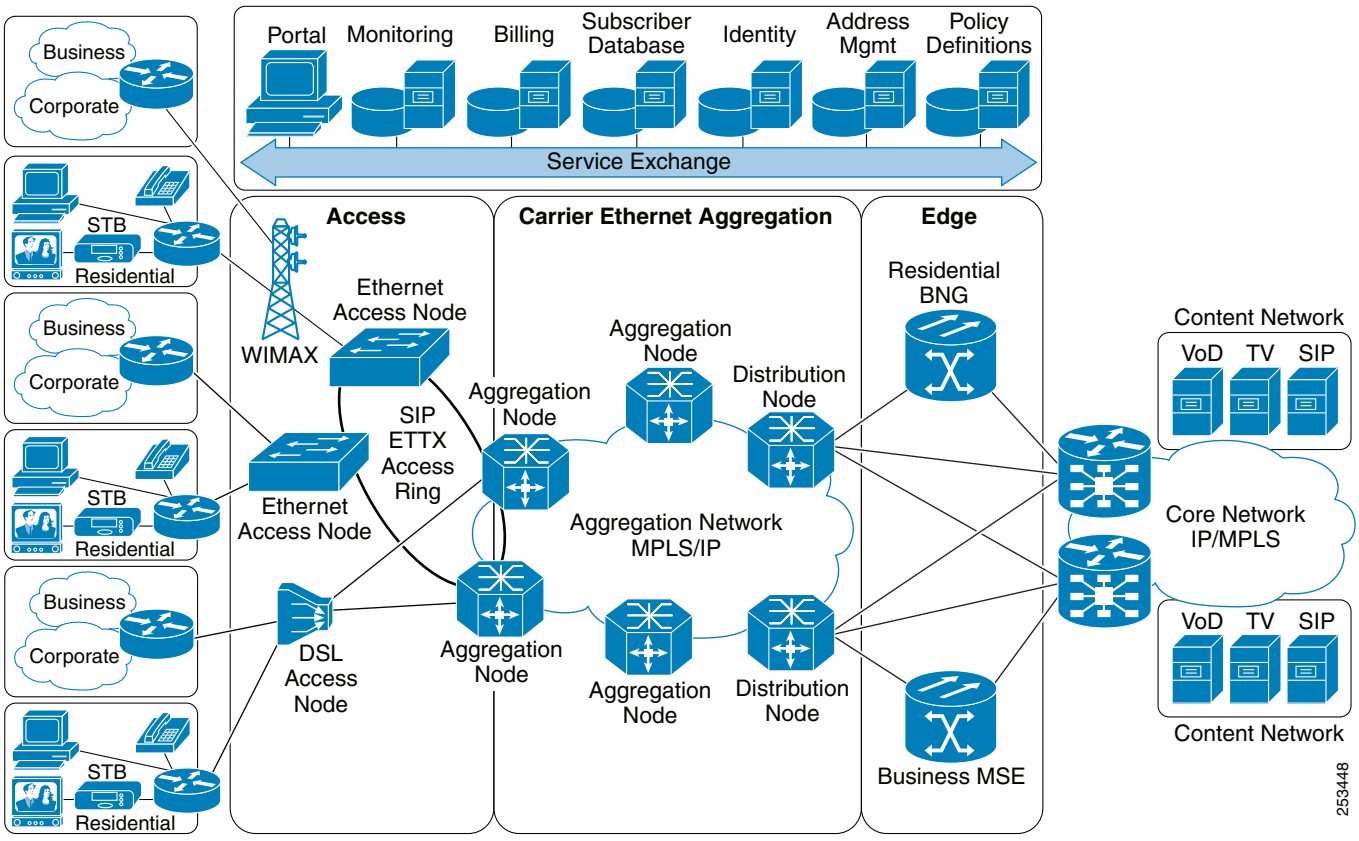
Cisco and the Metro Ethernet Forum (MEF) endorse these main L2 Ethernet service types. The names of the services differ, but their functionality is the same. These are the services:

- Ethernet Wire Service (EWS)
- Ethernet Relay Service (ERS)
- Ethernet Multipoint Service (EMS)
- Ethernet Flow Point (EFP)
- Ethernet Virtual Connection (EVC)

When discussing an Ethernet WAN (EWAN), these terminologies should be used:

- CE (customer edge): The customer device connecting to the service provider
- PE (provider edge): The service provider device connecting to the customer
- UNI: The connection between the CE and PE
- AC: The physical or virtual circuit attaching a CE to a PE.
- Multiplexed UNI: A UNI supporting multiple VLAN flows
- Pseudowire: A term used to indicate an end-to-end path in a service provider network

Figure 1 EWAN Terms



Ethernet Wire Service

An Ethernet Wire Service is a service that emulates a point-to-point Ethernet segment. This is similar to Ethernet private line (EPL), a Layer 1 point-to-point service, except the provider edge operates at L2 and typically runs over a L2+ network. The EWS encapsulates all frames that are received on a particular UNI and transports these frames to a single-egress UNI without reference to the contents contained within the frame. The operation of this service means that an EWS can be used with VLAN-tagged frames. The VLAN tags are transparent to the EWS (bridge protocol data units [BPDUs])—with some exceptions. These exceptions include IEEE 802.1x, IEEE 802.2ad, and IEEE 802.3x, because these frames have local significance and it benefits both the customer and SP to terminate them locally.

Since the service provider simply accepts frames on an interface and transmits these without reference to the actual frame (other than verifying that the format and length are legal for the particular interface) the EWS is indifferent to VLAN tags that may be present within the customer Ethernet frames.

EWS subscribes to the concept of all-to-one bundling. That is, an EWS maps a port on one end to a point-to-point circuit and to a port on another end. EWS is a port-to-port service. Therefore, if a customer needs to connect a switch or router to n switches or routers it will need n ports and n pseudowires or logical circuits.

One important point to consider is that, although the EWS broadly emulates an Ethernet Layer 1 connection, the service is provided across a shared infrastructure, and therefore it is unlikely that the full interface bandwidth will be, or needs to be, available at all times. EWS will typically be a sub-line rate service, where many users share a circuit somewhere in their transmission path. As a result, the cost will most likely be less than that of EPL. Unlike a Layer 1 EPL, the SP will need to implement QoS and traffic

engineering to meet the specific objectives of a particular contract. However, if the customer's application requires a true wire rate transparent service, then an EPL service—delivered using optical transmission devices such as DWDM (dense wavelength division multiplexing), CDWM (coarse wavelength division multiplexing), or SONET/SDH—should be considered.

Ethernet Relay Service

Ethernet Relay Service is similar to EWS in that it offers point-to-point connectivity. The key differentiation between EWS and ERS is that an ERS uses a VLAN tag to multiplex several, non-same-destination pseudowires to one port. That is, unlike EPL and EWS, ERS is a one-to-many multiplexed service. Service multiplexing simply means that multiple pseudowires utilize a single access interface or UNI. These circuits can terminate within an L2VPN or on, for example, an Internet gateway. From the service user's perspective, this service multiplexing capability offers more efficient interface utilization, simplification of cable plant, and reduced maintenance costs associated with additional interfaces.

Using the same example as above, where a router connects to n other routers, the source router only needs one port for the service instead of n, as is the case with an EWS. The service need not be port-to-port, but can be logical-pseudowire-to-logical-pseudowire. In the case of an ERS, each circuit can terminate at a different remote location (Figure 4), whereas using EWS, all frames are mapped to a single circuit and therefore a single egress point.

Figure 2 ERS Service Multiplexing Example: One Port (Left) Can Be Used for All Destinations (Right)

Like Frame Relay, ERS allows a customer device to access multiple connections through a single physical port attached to the service provider network. The service offered by ERS can be thought of as being similar in concept to Frame Relay, in that a VLAN number is used as a virtual circuit identifier in a similar fashion to Frame Relay data link connection identifier (DLCI). Unlike EWS, ERS does not forward BPDUs, because IEEE 802.1Q (VLAN tagging) only sends BPDUs on a default VLAN. In a hub-and-spoke network, only one spoke at most would receive BPDUs, thus breaking the spanning tree in the rest of the network. Therefore, an ERS does not transmit any BPDUs and runs routing protocols instead of Ethernet Spanning Tree. The routing protocols give the customer and provider greater flexibility, traffic determination characteristics, and value-added services.

Ethernet Multipoint Service

An Ethernet Multipoint Service (EMS) differs from EWS and ERS in that an EMS provides a multipoint connectivity model. It should be noted that an EMS service definition is still under review within the IETF Virtual Private LAN Service (VPLS) working group. Although EMS uses a multipoint model, it can forward unicast packets to single destinations; that is, it also supports point-to-point connections. To the end user, the network looks like a giant Ethernet switch where each customer has their own VLAN or broadcast domain, rather than end-to-end pseudowire link(s).

EMS Example

An EMS does not map an interface or VLAN to a specific point-to-point pseudowire. Instead, it models the operation of a virtual Ethernet switch: EMS uses the customer's MAC address to forward frames to the correct egress UNI within the service provider's network. An EMS emulates the service attributes of an Ethernet switch and learns source MAC to interface associations, floods unknown broadcast and multicast frames, and (optionally) monitors the service user's spanning tree protocol. One important point to note is that although the service provider may utilize spanning tree within the transport network, there is no interaction with the service user's spanning tree.

This service works similar to an MPLS VPN, except it functions at L2 instead of L3. While a VPLS EMS is a viable solution, its scalability and QoS control are suspect compared to that of MPLS VPNs. In addition, it is much more difficult, and may be impossible, for the service provider to offer value-added Layer 3 services (this is discussed later in the document).

Ethernet Flow Point

An Ethernet Flow Point (EFP) is a substream partition of a main interface. On Cisco ASR 9000 Series Routers, the EFP is implemented as an L2 subinterface with an encapsulation statement.

Ethernet Virtual Circuit

An Ethernet Virtual Circuit (EVC) is a point-to-point tunnel. On Cisco ASR 9000 Series Routers, the EVC is implemented as a pseudowire (PW).

Ethernet OAM Protocols

Ethernet as a Metro Area Network (MAN) or a Wide Area Network (WAN) technology benefits greatly from the implementation of Operations, Administration and Maintenance (OAM) features. OAM features allow Service Providers to monitor the quality of the connections on a MAN or WAN. Service providers can monitor specific events, take actions on events, and if necessary, put specific interfaces into loopback mode for troubleshooting. Ethernet OAM features can be configured to monitor either side or both sides of a link.

For more information on Ethernet OAM protocols, refer to the *Configuring Ethernet Interfaces on the Cisco ASR 9000 Series Router* module of the *Cisco ASR 9000 Series Aggregation Services Router Interface and Hardware Component Configuration Guide*.

Layer 2 VPN on Ethernet Interfaces

Layer 2 Virtual Private Network (L2VPN) connections emulate the behavior of a LAN across an IP or MPLS-enabled IP network, allowing Ethernet devices to communicate with each other as if they were connected to a common LAN segment.

The L2VPN feature enables service providers (SPs) to provide L2 services to geographically disparate customer sites. Typically, an SP uses an access network to connect the customer to the core network. This access network may use a mixture of L2 technologies, such as Ethernet and Frame Relay. The connection between the customer site and the nearby SP edge router is known as an attachment circuit (AC). Traffic from the customer travels over this link to the edge of the SP core network. The traffic then tunnels through a pseudowire over the SP core network to another edge router. The edge router sends the traffic down another AC to the customer's remote site.

The L2VPN feature enables the connection between different types of L2 attachment circuits and pseudowires, allowing users to implement different types of end-to-end services.

Cisco IOS XR software supports a point-to-point end-to-end service, where two Ethernet circuits are connected together. An L2VPN Ethernet port can operate in one of two modes:

- Port Mode—In this mode, all packets reaching the port are sent over the pseudowire, regardless of any VLAN tags that are present on the packets. In VLAN mode, the configuration is performed under the l2transport configuration mode.
- VLAN Mode—Each VLAN on a CE (customer edge) or access network to PE (provider edge) link can be configured as a separate L2VPN connection (using either VC type 4 or VC type 5). To configure L2VPN on VLANs, see the The Cisco ASR 9000 Series Routers Carrier Ethernet Model module in this manual. In VLAN mode, the configuration is performed under the individual subinterface.

Switching can take place in three ways:

- AC-to-PW—Traffic reaching the PE is tunneled over a PW (pseudowire) (and conversely, traffic arriving over the PW is sent out over the AC). This is the most common scenario.
- Local switching—Traffic arriving on one AC is immediately sent out of another AC without passing through a pseudowire.
- PW stitching—Traffic arriving on a PW is not sent to an AC, but is sent back into the core over another PW.

Keep these in mind when configuring L2VPN on an Ethernet interface:

- L2VPN links support QoS (Quality of Service) and MTU (maximum transmission unit) configuration.
- If your network requires that packets are transported transparently, you may need to modify the packet’s destination MAC (Media Access Control) address at the edge of the Service Provider (SP) network. This prevents the packet from being consumed by the devices in the SP network.

Use the **show interfaces** command to display AC and pseudowire information.

Gigabit Ethernet Protocol Standards Overview

The Gigabit Ethernet interfaces support these protocol standards:

- IEEE 802.3 Physical Ethernet Infrastructure
- IEEE 802.3ab 1000BASE-T Gigabit Ethernet
- IEEE 802.3z 1000 Mbps Gigabit Ethernet
- IEEE 802.3ae 10 Gbps Ethernet

These standards are further described in the sections that follow.

IEEE 802.3 Physical Ethernet Infrastructure

The IEEE 802.3 protocol standards define the physical layer and MAC sublayer of the data link layer of wired Ethernet. IEEE 802.3 uses Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access at a variety of speeds over a variety of physical media. The IEEE 802.3 standard covers 10 Mbps Ethernet. Extensions to the IEEE 802.3 standard specify implementations for Gigabit Ethernet, 10-Gigabit Ethernet, and Fast Ethernet.

IEEE 802.3ab 1000BASE-T Gigabit Ethernet

The IEEE 802.3ab protocol standards, or Gigabit Ethernet over copper (also known as 1000BaseT) is an extension of the existing Fast Ethernet standard. It specifies Gigabit Ethernet operation over the Category 5e/6 cabling systems already installed, making it a highly cost-effective solution. As a result, most copper-based environments that run Fast Ethernet can also run Gigabit Ethernet over the existing network infrastructure to dramatically boost network performance for demanding applications.

IEEE 802.3z 1000 Mbps Gigabit Ethernet

Gigabit Ethernet builds on top of the Ethernet protocol, but increases speed tenfold over Fast Ethernet to 1000 Mbps, or 1 Gbps. Gigabit Ethernet allows Ethernet to scale from 10 or 100 Mbps at the desktop to 100 Mbps up to 1000 Mbps in the data center. Gigabit Ethernet conforms to the IEEE 802.3z protocol standard.

By leveraging the current Ethernet standard and the installed base of Ethernet and Fast Ethernet switches and routers, network managers do not need to retrain and relearn a new technology in order to provide support for Gigabit Ethernet.

IEEE 802.3ae 10 Gbps Ethernet

Under the International Standards Organization's Open Systems Interconnection (OSI) model, Ethernet is fundamentally a L2 protocol. 10-Gigabit Ethernet uses the IEEE 802.3 Ethernet MAC protocol, the IEEE 802.3 Ethernet frame format, and the minimum and maximum IEEE 802.3 frame size. 10 Gbps Ethernet conforms to the IEEE 802.3ae protocol standards.

Just as 1000BASE-X and 1000BASE-T (Gigabit Ethernet) remained true to the Ethernet model, 10-Gigabit Ethernet continues the natural evolution of Ethernet in speed and distance. Because it is a full-duplex only and fiber-only technology, it does not need the carrier-sensing multiple-access with the CSMA/CD protocol that defines slower, half-duplex Ethernet technologies. In every other respect, 10-Gigabit Ethernet remains true to the original Ethernet model.

General Ethernet Standards

- Ethernet II framing also known as DIX.
- IEEE 802.3 framing also includes LLC and LLC/SNAP protocol frame formats
- IEEE 802.1d MAC Bridges and Spanning Tree—This standard specifies the MAC learning and MAC aging in a bridging environment. It also defines the original spanning tree protocol. Also MSTP is defined in IEEE 802.1s and IEEE 802.1q.
- IEEE 802.1q VLAN tagging—This standard defines VLAN tagging, and also the traditional VLAN trunking between switches. Technically, it also defines QinQ tagging, and MSTP. The Cisco ASR 9000 Series Routers do NOT support ISL.
- IEEE 802.1ad Provider Bridges—This standard is a subset of 802.1q and is often referred to as 802.1ad. The Cisco ASR 9000 Series Routers do not adhere to the entire standard, but large portions of the standard's functionality are supported.

MAC Address

A MAC address is a unique 6-byte address that identifies the interface at L2.

Ethernet MTU

The Ethernet maximum transmission unit (MTU) is the size of the largest frame, minus the 4-byte frame check sequence (FCS), that can be transmitted on the Ethernet network. Every physical network along the destination of a packet can have a different MTU.

Cisco IOS XR software supports two types of frame forwarding processes:

- Fragmentation for IPV4 packets—In this process, IPv4 packets are fragmented as necessary to fit within the MTU of the next-hop physical network.

  Note IPv6 does not support fragmentation.

- MTU discovery process determines largest packet size—This process is available for all IPV6 devices, and for originating IPv4 devices. In this process, the originating IP device determines the size of the largest IPv6 or IPV4 packet that can be sent without being fragmented. The largest packet is equal to the smallest MTU of any network between the IP source and the IP destination devices. If a packet is larger than the smallest MTU of all the networks in its path, that packet will be fragmented as necessary. This process ensures that the originating device does not send an IP packet that is too large.

Jumbo frame support is automatically enable for frames that exceed the standard frame size. The default value is 1514 for standard frames and 1518 for 802.1Q tagged frames. These numbers exclude the 4-byte frame check sequence (FCS).

Flow Control on Ethernet Interfaces

The flow control used on 10-Gigabit Ethernet interfaces consists of periodically sending flow control pause frames. It is fundamentally different from the usual full- and half-duplex flow control used on standard management interfaces. On the Cisco ASR 9000 Series Routers both ingress & egress flow control are off by default.

VRRP

The Virtual Router Redundancy Protocol (VRRP) eliminates the single point of failure inherent in the static default routed environment. VRRP specifies an election protocol that dynamically assigns responsibility for a virtual router to one of the VPN concentrators on a LAN. The VRRP VPN concentrator controlling the IP addresses associated with a virtual router is called the master, and forwards packets sent to those IP addresses. When the master becomes unavailable, a backup VPN concentrator takes the place of the master.

For more information on VRRP, see the *Implementing VRRP* module of *Cisco ASR 9000 Series Routers IP Addresses and Services Configuration Guide.*

HSRP

Hot Standby Routing Protocol (HSRP) is a proprietary protocol from Cisco. HSRP is a routing protocol that provides backup to a router in the event of failure. Several routers are connected to the same segment of an Ethernet, FDDI, or token-ring network and work together to present the appearance of a single virtual router on the LAN. The routers share the same IP and MAC addresses and therefore, in the event of failure of one router, the hosts on the LAN are able to continue forwarding packets to a consistent IP and MAC address. The transfer of routing responsibilities from one device to another is transparent to the user.

HSRP is designed to support non disruptive failover of IP traffic in certain circumstances and to allow hosts to appear to use a single router and to maintain connectivity even if the actual first hop router they are using fails. In other words, HSRP protects against the failure of the first hop router when the source host cannot learn the IP address of the first hop router dynamically. Multiple routers participate in HSRP and in concert create the illusion of a single virtual router. HSRP ensures that one and only one of the routers is forwarding packets on behalf of the virtual router. End hosts forward their packets to the virtual router.

The router forwarding packets is known as the *active router.* A standby router is selected to replace the active router should it fail. HSRP provides a mechanism for determining active and standby routers, using the IP addresses on the participating routers. If an active router fails a standby router can take over without a major interruption in the host's connectivity.

HSRP runs on top of User Datagram Protocol (UDP), and uses port number 1985. Routers use their actual IP address as the source address for protocol packets, not the virtual IP address, so that the HSRP routers can identify each other.

For more information on HSRP, see the *Implementing HSRP* module of *Cisco ASR 9000 Series Routers IP Addresses and Services Configuration Guide.*

Link Autonegotiation on Ethernet Interfaces

Link autonegotiation ensures that devices that share a link segment are automatically configured with the highest performance mode of interoperation. Use the **negotiation auto** command in interface configuration mode to enable link autonegotiation on an Ethernet interface. On line card Ethernet interfaces, link autonegotiation is disabled by default.

Note The **negotiation auto** command is available on Gigabit Ethernet interfaces only.

What is an Ethernet Flow Point?

An Ethernet flow point (EFP) is a Layer 2 logical subinterface used to classify traffic under a physical or a bundle interface.

A physical interface can be a Gigabit Ethernet 0/0/0/1 or a 10 Gigabit Ethernet 0/0/0/0 interface and has ports on the line card. A bundle interface is a virtual interface, created by grouping physical interfaces together.

For example, physical interfaces such as Gigabit Ethernet 0/0/0/1 and 10 Gigabit Ethernet 0/0/0/0 can be configured as members of a bundle interface.

Grouping physical interfaces together can:

- Reduce the routing entries
- Increase the bandwidth of the bundle interface
- Balance the traffic on the bundle members

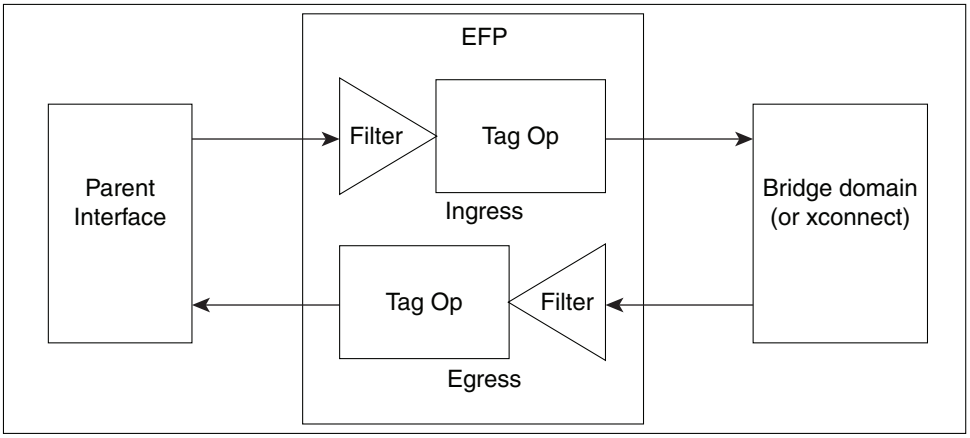
EFP has the following characteristics:

- An EFP represents a logical demarcation point of an Ethernet virtual connection (EVC) on an interface. For an EVC associating two or more UNIs, there is a flow point on each interface of every device, through which that EVC passes.
- An EFP can be regarded as an instantiation of a particular service. An EFP is defined by a set of filters. These filters are applied to all the ingress traffic to classify the frames that belong to a particular EFP. An EFP *filter* is a set of entries, where each entry looks similar to the start of a packet (ignoring source/destination MAC address). Each entry usually contains 0, 1 or 2 VLAN tags. A packet that starts with the same tags as an entry in the filter is said to match the filter; if the start of the packet does not correspond to any entry in the filter then the packet does not match the filter.
- An EFP serves four purposes:
  - Identifies all frames that belong to a particular flow on a given interface
  - Performs ingress and egress Ethernet header manipulations
  - Adds features to the identified frames
  - Optionally define how to forward those frames in the data path

You can perform a variety of operations on the traffic flows when a router is configured with EFPs on various interfaces. Also, you can bridge or tunnel the traffic by many ways from one or more of the router's ingress EFPs to one or more egress EFPs. This traffic is a mixture of VLAN IDs, single or double (QinQ) encapsulation, and ethertypes.

Figure 3 shows the EFP model.

Figure 3 EFP Model



An EFP subinterface is configured to specify which traffic on ingress is vectored to that EFP. This is done by specifying a VLAN, range of VLANs, or QinQ tagging to match against on ingress. All traffic on ingress is compared to each EFP's matching criterion, and processed by that EFP if a match occurs. The processing performed by an EFP can change VLAN IDs, add or remove VLAN tags, and change ethertypes.

Improving the Scalability of EFPs on Bundle Interfaces

You can improve the scalability of EFPs on bundle interfaces in two ways:

- Increase the number of EFPs per chassis from 32000 to 64000.
- Increase the number of EFPs per line card, on a single node point, to the same scale as the physical interface scaling.

The following example illustrates how to improve the scalability of EFPs per line card:

Consider a B module line card type[1] with a bundle interface scaling of 4000 and a physical interface scaling of 16000. The scalability of EFPs on the B module is improved by adding three additional bundles of 4000 EFPs per bundle.

Note The maximum number of EFPs that can be added to a bundle interface is 4000.

The number of EFPs per line card is now scaled to 16000 or 4 bundles of 4000 EFPs each.

EFP CLI Overview

Cisco IOS XR implements a structured CLI for EFP and EVC configuration. These commands are typically used to configure an EFP:

- **l2transport** command - This command identifies a subinterface (or a physical port or bundle-port parent interface) as an EFP.
- **encapsulation** command - This command is used to specify matching criteria.
- **rewrite** command - This command is used to specify the VLAN tag rewrite criteria.

1. One of the line card types that the ASR 9000 Series Router supports.

Egress EFP Filtering

The Egress EFP Filtering feature implements a means of filtering EFP egress traffic, ensuring that all the given EFP's egress traffic complies with the ingress matching criterion.

An ingress EFP is similar to an egress EFP. The router is configured to send traffic on the EFP, that matches that EFP's ingress matching criterion. It is possible to configure a router so that this does not occur, and there is no safeguard to prevent such mismatching egress EFP traffic from exiting the router.

The Cisco ASR 9000 Series Routers allows for different VLANs on different ports within the same bridge domain. This allows a bridge to forward a packet out of a port not configured for the VLAN tag on the packet. Egress EFP filtering checks this and drops invalid packets at the egress port.

Identifying Frames of an EFP

The EFP identifies frames belonging to a particular flow on a given port, independent of their Ethernet encapsulation. An EFP can flexibly map frames into a flow or EFP based on the fields in the frame header.

The frames can be matched to an EFP using

- VLAN tag or tags
- MAC address (source address, destination address, or both)
- 802.1p CoS bits
- Logical conjunction of two or more of the above: VLAN, MAC, and CoS
- Default match (that is, any other traffic that has not matched a more specific EFP)
- Protocol ethertype

The frames cannot be matched to an EFP through use of any of these:

- Any information outside the outermost Ethernet frame header and its associated tags such as
  - IPv4, IPv6, or MPLS tag header data
  - C-DMAC, C-SMAC, or C-VLAN
- Logical disjunction of the valid frame matches above: VLAN, MAC, and CoS

The specific match criteria are covered in more detail in these sections.

VLAN Tag Matching

Table 1 describes the different encapsulation types and the EFP identifier corresponding to each.

Table 1 VLAN Tag Matching

Encapsulation Type	EFP Identifier
Untagged	Static configuration on the ingress physical interface or a subinterface that uses the **untagged** keyword in the **encapsulation** command. There can be only one untagged subinterface. If an untagged subinterface has been created, traffic goes to this interface instead of the main interface.
Priority-tagged Ethernet frames	A priority-tagged frame is defined as having a single 802.1Q VLAN header, with a VLAN id of zero.
Native VLAN	Cisco ASR 9000 Series Routers do not support native VLAN. Use this command: **encapsulation dot1q** <*vlan-id*>, **untagged**
Single tagged frames	802.1Q customer-tagged Ethernet frames
Double tagged frames	802.1Q (ethertype 0x8100) double tagged frames 802.1ad double tagged frames Legacy 0x9100 and 0x9200 double tagged frames
Default tagging	An EFP which has a maximum-match wildcard. The effect is to receive any traffic that does not match any other EFP on the same physical interface.

You can use wildcards as well as VLAN ranges while defining frames that map to a given EFP. EFPs can distinguish flows based on a single VLAN tag, a range of VLAN tags, a stack of VLAN tags or a combination of both (VLAN stack with wildcards). It provides the EFP model, a flexibility of being encapsulation agnostic, and allows it to be extensible as new tagging or tunneling schemes are added.

MAC Address Matching

The source MAC address, the destination MAC address, or both can be matched. In all cases, the MAC address requires an exact match. A wildcard match or partial match is not adequate.

802.1p CoS Bits Matching

One or more exact CoS matches are specified. Because CoS is only 3 bits, this limits it to 8 possible choices.

Logical Conjunction

All of the match criteria above can be selectively combined those frames that match all of the separate criteria.

Default Match

A single EFP can be defined that matches all other traffic that has not been matched by a more specific EFP.

Match Precedence and Config Verification

Overlapping EFPs are allowed to be configured, where it is possible to determine an order in which they should be used for matching. But EFPs that conflict with other EFPs or subinterfaces on the parent trunk interface should be blocked at config verification.

An ordering precedence is used for how EFP matches are applied in hardware. The model is for matches that are more specific to be processed before matches that are less specific.

Egress Behavior

The EFP matching criteria can also be used on egress to police the frames that can egress from the EFP, based on the platform support. Frames that do not match the criteria (source/destination MAC match criteria are reversed) are dropped.

Applying Features

After the frames are matched to a particular EFP, any appropriate features can be applied. In this context, “features” means any frame manipulations specified by the configuration as well as things such as QoS and ACLs. The Ethernet infrastructure provides an appropriate interface to allow the feature owners to apply their features to an EFP. Hence, IM interface handles are used to represent EFPs, allowing feature owners to manage their features on EFPs in the same way the features are managed on regular interfaces or subinterfaces.

The only L2 features that can be applied on an EFP that is part of the Ethernet infrastructure are the L2 header encapsulation modifications. The L2 features are described in this section.

Encapsulation Modifications

EFP supports these L2 header encapsulation modifications on both ingress and egress:

- Push 1 or 2 VLAN tags
- Pop 1 or 2 VLAN tags

Note This modification can only pop tags that are matched as part of the EFP.

- Rewrite 1 or 2 VLAN tags:
  - Rewrite outer tag
  - Rewrite outer 2 tags
  - Rewrite outer tag and push an additional tag
  - Remove outer tag and rewrite inner tag

For each of the VLAN ID manipulations, these can be specified:

- The VLAN tag type, that is, C-VLAN, S-VLAN, or I-TAG. The ethertype of the 802.1Q C-VLAN tag is defined by the dot1q tunneling type command.
- The VLAN ID. 0 can be specified for an outer VLAN tag to generate a priority-tagged frame.

Note For tag rewrites, the CoS bits from the previous tag should be preserved in the same way as the DEI bit for 802.1ad encapsulated frames.

Defining Data-Forwarding Behavior

The EFP can be used to designate the frames belonging to a particular Ethernet flow forwarded in the data path. These forwarding cases are supported for EFPs in Cisco IOS XR software:

- L2 Switched Service (Bridging)—The EFP is mapped to a bridge domain, where frames are switched based on their destination MAC address. This includes multipoint services:
  - Ethernet to Ethernet Bridging
  - Virtual Private LAN Service (VPLS)
- L2 Stitched Service (AC to AC xconnect)—This covers point-to-point L2 associations that are statically established and do not require a MAC address lookup.
  - Ethernet to Ethernet Local Switching—The EFP is mapped to an S-VLAN either on the same port or on another port. The S-VLANs can be identical or different.
- Tunneled Service (xconnect)—The EFP is mapped to a Layer 3 tunnel. This covers point-to-point services only:
  - EoMPLS
  - L2TPv3
- L2 Terminated Service (Ethernet access to Layer 3 service)—The EFP is mapped to an IP interface that has a global address or belongs to a VRF (includes both IP and MPLS Layer 3 VPNs).

802.1Q VLAN

A VLAN is a group of devices on one or more LANs that are configured so that they can communicate as if they were attached to the same wire, when in fact they are located on a number of different LAN segments. Because VLANs are based on logical instead of physical connections, it is very flexible for user and host management, bandwidth allocation, and resource optimization.

The IEEE's 802.1Q protocol standard addresses the problem of breaking large networks into smaller parts so broadcast and multicast traffic does not consume more bandwidth than necessary. The standard also helps provide a higher level of security between segments of internal networks.

The 802.1Q specification establishes a standard method for inserting VLAN membership information into Ethernet frames.

Cisco IOS XR software supports VLAN subinterface configuration on Gigabit Ethernet and10-Gigabit Ethernet interfaces.

802.1Q Tagged Frames

The IEEE 802.1Q tag-based VLAN uses an extra tag in the MAC header to identify the VLAN membership of a frame across bridges. This tag is used for VLAN and quality of service (QoS) priority identification. The VLANs can be created statically by manual entry or dynamically through Generic Attribute Registration Protocol (GARP) VLAN Registration Protocol (GVRP). The VLAN ID associates a frame with a specific VLAN and provides the information that switches must process the frame across the network. A tagged frame is four bytes longer than an untagged frame and contains two bytes of Tag Protocol Identifier (TPID) residing within the type and length field of the Ethernet frame and two bytes of Tag Control Information (TCI) which starts after the source address field of the Ethernet frame.

Subinterfaces

Subinterfaces are logical interfaces created on a hardware interface. These software-defined interfaces allow for segregation of traffic into separate logical channels on a single hardware interface as well as allowing for better utilization of the available bandwidth on the physical interface.

Subinterfaces are distinguished from one another by adding an extension on the end of the interface name and designation. For instance, the Ethernet subinterface 23 on the physical interface designated TenGigE 0/1/0/0 would be indicated by TenGigE 0/1/0/0.23.

Before a subinterface is allowed to pass traffic it must have a valid tagging protocol encapsulation and VLAN identifier assigned. All Ethernet subinterfaces always default to the 802.1Q VLAN encapsulation. However, the VLAN identifier must be explicitly defined.

Subinterface MTU

The subinterface maximum transmission unit (MTU) is inherited from the physical interface with an additional four bytes allowed for the 802.1Q VLAN tag.

VLAN Subinterfaces on Ethernet Bundles

An Ethernet bundle is a group of one or more Ethernet ports that are aggregated together and treated as a single link. Multiple VLAN subinterfaces can be added to a single Ethernet bundle.

For more information about configuring Ethernet bundles, see the Configuring Link Bundles module in this document. The procedure for creating VLAN subinterfaces on an Ethernet bundle is exactly the same as the procedure for creating VLAN subinterfaces on a physical Ethernet interface.

To create a VLAN subinterface on an Ethernet bundle, see the Configuring 802.1Q VLAN Interfaces, page 47 section later in this module.

Layer 2 VPN on VLANs

The Layer 2 Virtual Private Network (L2VPN) feature enables Service Providers (SPs) to provide L2 services to geographically disparate customer sites, as described in the Layer 2 VPN on Ethernet Interfaces, page 23 section of the Configuring Ethernet Interfaces, page 37 module earlier in this manual.

The configuration model for configuring VLAN attachment circuits (ACs) is similar to the model used for configuring basic VLANs, where the user first creates a VLAN subinterface, and then configures that VLAN in subinterface configuration mode. To create an Attachment Circuit, you need to include the **l2transport** keyword in the **interface** command string to specify that the interface is a L2 interface.

VLAN ACs support three modes of L2VPN operation:

- Basic Dot1Q Attachment Circuit—The Attachment Circuit covers all frames that are received and sent with a specific VLAN tag.
- QinQ Attachment Circuit—The Attachment Circuit covers all frames received and sent with a specific outer VLAN tag and a specific inner VLAN tag. QinQ is an extension to Dot1Q that uses a stack of two tags.
- Q-in-Any Attachment Circuit—The Attachment Circuit covers all frames received and sent with a specific outer VLAN tag and any inner VLAN tag, as long as that inner VLAN tag is not Layer 3 terminated. Q-in-Any is an extension to QinQ that uses wildcarding to match any second tag.

Note The Q-in-Any mode is a variation of the basic Dot1Q mode. In Q-in-Any mode, the frames have a basic QinQ encapsulation; however, in Q-in-Any mode the inner tag is not relevant, except for the fact that a few specific inner VLAN tags are siphoned for specific services. For example, a tag may be used to provide L3 services for general internet access.

Each VLAN on a CE-to-PE link can be configured as a separate L2VPN connection (using either VC type 4 or VC type 5). To configure L2VPN on VLANs, see the "Removing an 802.1Q VLAN Subinterface" section on page 52.

Keep these in mind when configuring L2VPN on a VLAN:

- Cisco IOS XR software supports 4000 Attachment Circuits per line card.
- In a point-to-point connection, the two Attachment Circuits do not have to be of the same type. For example, a port mode Ethernet Attachment Circuit can be connected to a Dot1Q Ethernet Attachment Circuit.
- Pseudowires can run in VLAN mode or in port mode. A pseudowire running in VLAN mode has a single Dot1Q tag, while a pseudo-wire running in port mode has no tags. Some interworking is required to connect these different types of circuits together. This interworking takes the form of popping, pushing, and rewriting tags. The advantage of L2VPN is that is simplifies the interworking required to connect completely different media types together.
- The Attachment Circuits on either side of an MPLS pseudowire can be different types. In this case, the appropriate conversion is carried out at one or both ends of the Attachment Circuit to pseudowire connection.

Use the **show interfaces** command to display Attachment Circuit and pseudowire information.

Note For more information on the **show interfaces** command, refer to the *Cisco ASR 9000 Series Aggregation Services Router Interface and Hardware Component Command Reference.*

How to Configure Layer 2 Features on Ethernet Interfaces

These tasks are described in this section:

Note For more information on configuring interfaces, refer to the *Cisco ASR 9000 Series Aggregation Services Router Interface and Hardware Component Configuration Guide.*

Default Configuration Values for Gigabit Ethernet and 10-Gigabit Ethernet

Table 2 describes the default interface configuration parameters that are present when an interface is enabled on a Gigabit Ethernet or 10-Gigabit Ethernet modular services card and its associated PLIM.

Note You must use the **shutdown** command to bring an interface administratively down. The interface default is **no shutdown**. When a modular services card is first inserted into the router, if there is no established preconfiguration for it, the configuration manager adds a shutdown item to its configuration. This shutdown can be removed only be entering the **no shutdown** command.

Table 2 Gigabit Ethernet and 10-Gigabit Ethernet Modular Services Card Default Configuration Values

Parameter	Configuration File Entry	Default Value	Restrictions[1]
Flow control	**flow-control**	egress on ingress off	none
MTU	**mtu**	1514 bytes for normal frames 1518 bytes for 802.1Q tagged frames 1522 bytes for QinQ frames	none
MAC address	**mac address**	Hardware burned-in address (BIA[2])	L3 only
L2 port	**l2transport**	off/L3	L2 subinterfaces must have L3 main parent interface
Egress filtering	**Ethernet egress-filter**	off	none
Link negotiation	**negotiation**	off	physical main interfaces only
Tunneling Ethertype	**tunneling ethertype**	0X8100	configured on main interface only; applied to subinterfaces only
VLAN tag matching	**encapsulation**	all frames for main interface; only ones specified for subinterfaces	encapsulation command only subinterfaces

1. The restrictions are applicable to L2 main interface, L2 subinterface, L3 main interface, interflex L2 interface etc.
2. burned-in address

1. burned-in address

Configuring Ethernet Interfaces

These tasks are described in this section:

- Configuring a 10-Gigabit Ethernet Interface
- Configuring a Gigabit Ethernet Interface

For more information on configuring Ethernet interfaces, see the *Cisco ASR 9000 Series Aggregation Services Router Interface and Hardware Component Configuration Guide*.

Configuring a 10-Gigabit Ethernet Interface

Perform this task to configure an Ethernet interface:

SUMMARY STEPS

1. **configure interface TenGigE** [*instance*]
2. **l2transport**
3. **mtu** *bytes*
4. **no shutdown**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure interface TenGigE** [*instance*] **Example:** `RP/0/RSP0/CPU0:router# configure` `RP/0/RSP0/CPU0:router(config)# interface TenGigE 0/0/0/1`	Enters interface configuration mode for a 10-Gigabit Ethernet interface.
Step 2	**l2transport** **Example:** `RP/0/RSP0/CPU0:router(config-if)#l2transport`	Enables Layer 2 transport mode on a port and enter Layer 2 transport configuration mode.
Step 3	**mtu** *bytes* **Example:** `RP/0/RSP0/CPU0:router(config-if-l2)# mtu 1448`	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 4	**no shutdown** **Example:** `RP/0/RSP0/CPU0:router(config-if-l2)# no shutdown`	Removes the shutdown configuration, which forces an interface administratively down.

	Command or Action	Purpose
Step 5	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-if-l2)# end` or `RP/0/RSP0/CPU0:router(config-if-l2)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring a Gigabit Ethernet Interface

Perform this task to configure a basic Gigabit Ethernet or 10-Gigabit Ethernet interface:

SUMMARY STEPS

1. **configure**
2. **interface** *type interface-path-id*
3. **ipv4 address** *ip-address mask*
4. **flow-control** {**bidirectional | egress | ingress**}
5. **mtu** *bytes*
6. **mac-address** *value1.value2.value3*
7. **negotiation auto** (on Gigabit Ethernet interfaces only)
8. **no shutdown**
9. **end**
   or
   commit
10. **show interfaces** [**GigabitEthernet | TenGigE**] *instance*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure terminal`	Enters global configuration mode.
Step 2	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/1/0/0`	Enters interface configuration mode and specifies the Ethernet interface name and notation *rack/slot/module/port*.

	Command or Action	Purpose
Step 3	**ipv4 address** *ip-address mask* **Example:** `RP/0/RSP0/CPU0:router(config-if)# ipv4 address 172.18.189.38 255.255.255.224`	Assigns an IP address and subnet mask to the interface. • Replace *ip-address* with the primary IPv4 address for the interface. • Replace *mask* with the mask for the associated IP subnet. The network mask can be specified in either of two ways: – The network mask can be a four-part dotted decimal address. For example, 255.0.0.0 indicates that each bit equal to 1 means that the corresponding address bit belongs to the network address. – The network mask can be indicated as a slash (/) and number. For example, /8 indicates that the first 8 bits of the mask are ones, and the corresponding bits of the address are network address.
Step 4	**flow-control** {**bidirectional**| **egress** | **ingress**} **Example:** `RP/0/RSP0/CPU0:router(config-if)# flow control ingress`	(Optional) Enables the sending and processing of flow control pause frames. • **egress**—Enables the sending of flow control pause frames in egress. • **ingress**—Enables the processing of received pause frames on ingress. • **bidirectional**—Enables the sending of flow control pause frames in egress and the processing of received pause frames on ingress.
Step 5	**mtu** *bytes* **Example:** `RP/0/RSP0/CPU0:router(config-if)# mtu 1448`	(Optional) Sets the MTU value for the interface. • The default is 1514 bytes for normal frames and 1518 bytes for 802.1Q tagged frames. • The range for Gigabit Ethernet and 10-Gigabit Ethernet mtu values is 64 bytes to 65535 bytes.
Step 6	**mac-address** *value1.value2.value3* **Example:** `RP/0/RSP0/CPU0:router(config-if)# mac address 0001.2468.ABCD`	(Optional) Sets the MAC layer address of the Management Ethernet interface. • The values are the high, middle, and low 2 bytes, respectively, of the MAC address in hexadecimal. The range of each 2-byte value is 0 to ffff.
Step 7	**negotiation auto** **Example:** `RP/0/RSP0/CPU0:router(config-if)# negotiation auto`	(Optional) Enables autonegotiation on a Gigabit Ethernet interface. • Autonegotiation must be explicitly enabled on both ends of the connection, or speed and duplex settings must be configured manually on both ends of the connection. • If autonegotiation is enabled, any manually configured speed or duplex settings take precedence. **Note** The **negotiation auto** command is available on Gigabit Ethernet interfaces only.

	Command or Action	Purpose
Step 8	**no shutdown** **Example:** `RP/0/RSP0/CPU0:router(config-if)# no shutdown`	Removes the shutdown configuration, which forces an interface administratively down.
Step 9	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-if)# end` or `RP/0/RSP0/CPU0:router(config-if)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 10	**show interfaces** [**GigabitEthernet** | **TenGigE**] *instance* **Example:** `RP/0/RSP0/CPU0:router# show interfaces TenGigE 0/3/0/0`	(Optional) Displays statistics for interfaces on the router.

What to Do Next

- To configure an 802.1Q VLAN subinterface on the Ethernet interface, see the "The Cisco ASR 9000 Series Routers Carrier Ethernet Model" module later in this manual.
- To configure an AC on the Ethernet port for L2VPN implementation, see the "Configuring an Attachment Circuit on an Ethernet Port" section later in this module.

Configuring an Attachment Circuit on an Ethernet Port

Use this procedure to configure an attachment circuit on a Gigabit Ethernet or 10-Gigabit Ethernet port. For more information on configuring an attachment circuit, refer to the *Cisco ASR 9000 Series Aggregation Services Router Interface and Hardware Component Configuration Guide*.

Note The steps in this procedure configure the L2VPN Ethernet port to operate in EFP mode.

SUMMARY STEPS

1. **configure**
2. **interface** [**GigabitEthernet | TenGigE**] *instance.subinterface* **l2transport**
3. **encapsulation dot1q** *vlan-id*
4. **interface** [**GigabitEthernet | TenGigE**] *instance.subinterface* **l2transport**
5. **encapsulation dot1q** *vlan-id*
6. **l2vpn**
7. **bridge group** *group-name*
8. **bridge-domain** *domain-name*
9. **interface** [**GigabitEthernet | TenGigE**] *instance.subinterface*
10. **interface** [**GigabitEthernet | TenGigE**] *instance.subinterface*
11. **end**
    or
    commit
12. **show run interface** [**GigabitEthernet | TenGigE**] *instance.subinterface*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface [GigabitEthernet | TenGigE]** *instance.subinterface* **l2transport** Example: `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet0/5/0/0.20 l2transport`	Enters subinterface configuration mode and specifies the interface type, location, and subinterface number. • Replace the instance argument with one of these instances: – Physical Ethernet interface instance, or with an Ethernet bundle instance. Naming notation is rack/slot/module/port, and a slash between values is required as part of the notation. – Ethernet bundle instance. Range is from 1 through 65535. • Replace the subinterface argument with the subinterface value. Range is from 0 through 4095. • Naming notation is instance.subinterface, and a period between arguments is required as part of the notation.
Step 3	**encapsulation dot1q** *vlan-id* **Example:** `RP/0/RSP0/CPU0:router(config-subif)#encapsulation dot1q 50`	Assigns the matching VLAN ID and Ethertype to the interface.
Step 4	**interface [GigabitEthernet | TenGigE]** *instance.subinterface* **l2transport** Example: `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet0/5/0/0.20 l2transport`	Enters subinterface configuration mode and specifies the interface type, location, and subinterface number. • Replace the instance argument with one of these instances: – Physical Ethernet interface instance, or with an Ethernet bundle instance. Naming notation is rack/slot/module/port, and a slash between values is required as part of the notation. – Ethernet bundle instance. Range is from 1 through 65535. • Replace the subinterface argument with the subinterface value. Range is from 0 through 4095. • Naming notation is instance.subinterface, and a period between arguments is required as part of the notation.
Step 5	**encapsulation dot1q** *vlan-id* **Example:** `RP/0/RSP0/CPU0:router(config-subif)#encapsulation dot1q 50`	Assigns the matching VLAN ID and Ethertype to the interface.

	Command or Action	Purpose
Step 6	**l2vpn** **Example:** `RP/0/RSP0/CPU0:router(config-subif)#l2vpn`	Enters L2VPN configuration mode.
Step 7	**bridge group** *bridge-group-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)#bridge group ce-doc-examples`	Enters configuration mode for the named bridge group. This command creates a new bridge group or modifies the existing bridge group if it already exists. A bridge group organizes bridge domains.
Step 8	**bridge-domain domain-name** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg)#bridge-domain ac-example`	Enters configuration mode for the named bridge domain. This creates a new bridge domain modifies the existing bridge domain if it already exists.
Step 9	**interface [GigabitEthernet | TenGigE] instance.subinterface** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#interface GigabitEthernet0/5/0/0.20`	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. The interface EFP now becomes an attachment circuit on this bridge domain.
Step 10	**interface [GigabitEthernet | TenGigE] instance.subinterface** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#interface GigabitEthernet0/5/0/1.15`	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. The interface EFP now becomes an attachment circuit on this bridge domain.

	Command or Action	Purpose
Step 11	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 12	**show run interface** [**GigabitEthernet** | **TenGigE**] *instance.subinterface* **Example:** `RP/0/RSP0/CPU0:router#show run interface GigabitEthernet0/5/0/1.15`	(Optional) Displays statistics for the subinterface on the router.

Configuring Egress EFP Filtering

This section describes the procedures for configuring the egress EFP filtering feature on the Cisco ASR 9000 Series Routers.

Egress EFP filtering is a L2 subinterface specific feature that controls how strictly subinterface encapsulation filtering is performed in the egress direction. According to the EFP behavior and model, all packets transmitted out of a subinterface should match the subinterface encapsulation or rewrite criteria if the same packet is to be received on the subinterface (with the source and destination MAC addresses swapped).

Egress EFP filtering has two stages; first stage is without rewrite command, and the second stage is with rewrite command.

In the first stage filtering, the packet is checked against the encapsulation to ensure the match, the same way it is checked on ingress to determine that the packet is forwarded to that EFP.

In the second stage filtering, the packet is checked before the egress rewrite occurs to ensure that the packet in its egress pre-rewrite state is correct. This means that the egress packet's VLAN encapsulation should be same as a hypothetical ingress packet after the ingress rewrite occurs.

In case of an interface configured with both a rewrite and egress EFP filtering, where egress traffic is getting dropped unexpectedly due to egress EFP filtering, the user must first ascertain which stage the drops occur.

Note Output drops counter displays the drops occurred due to egress EFP filtering in the "show interface" display for that interface. Output drops counter is a summation of drops from multiple causes and not necessarily due to egress EFP filtering.

By using the **ethernet egress-filter** command, you can configure egress EFP filtering in either global or L2 subinterface mode:

- **ethernet egress-filter strict** configures Egress EFP Filtering in global configuration mode.
- **ethernet egress-filter {strict | disabled}** configures Egress EFP Filtering in L2 subinterface mode.

SUMMARY STEPS

1. **configure**
2. **ethernet egress-filter strict**
3. **interface {GigabitEthernet | TenGigE | FastEthernet | Bundle-Ether}** instance.subinterface
4. **ethernet egress-filter {strict | disabled}**
5. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:PE44_ASR-9010# config` `Thu Jun  4 07:50:02.660 PST` `RP/0/RSP0/CPU0:PE44_ASR-9010(config)#`	Enters global configuration mode.
Step 2	**ethernet egress-filter strict** **Example:** `RP/0/RSP0/CPU0:PE44_ASR-9010(config)#` `ethernet egress-filter strict`	Enables strict egress filtering on all subinterfaces on the device by default.
Step 3	**interface {GigabitEthernet | TenGigE | FastEthernet | Bundle-Ether}** instance.subinterface **Example:** `RP/0/RSP0/CPU0:PE44_ASR-9010(config)#` `interface GigabitEthernet 0/1/0/1.1` `RP/0/RSP0/CPU0:PE44_ASR-9010(config-subif` `)#`	Creates an L2 subinterface.

	Command or Action	Purpose
Step 4	**ethernet egress-filter {strict | disabled}** **Example:** `RP/0/RSP0/CPU0:PE44_ASR-9010(config-subif)# ethernet egress-filter strict`	Allows egress filtering to be explicitly enabled or disabled on any L2 subinterface. It can also be used to override global settings.
Step 5	**exit** **Example:** `RP/0/RSP0/CPU0:PE44_ASR-9010(config-subif)# exit` `RP/0/RSP0/CPU0:PE44_ASR-9010(config)# exit`	Exit from the configuration mode.

Configuring 802.1Q VLAN Interfaces

This section contains these procedures:

Configuring 802.1Q VLAN Subinterfaces

This task explains how to configure 802.1Q VLAN subinterfaces. To remove these subinterfaces, see the "Removing an 802.1Q VLAN Subinterface" section of this module.

SUMMARY STEPS

1. **configure**
2. **interface** {**GigabitEthernet** | **TenGigE** | **Bundle-Ether**} *instance.subinterface*
3. **l2transport**
4. **encapsulation dot1q** *vlan-id*
5. **ethernet egress-filter strict**
6. **end**
   or
   commit
7. **show ethernet trunk bundle-ether** *instance* (Optional)

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface** {**GigabitEthernet** | **TenGigE** | **Bundle-Ether**} *instance.subinterface* **Example:** `RP/0/RSP0/CPU0:router(config)# interface TenGigE 0/2/0/4.10`	Enters subinterface configuration mode and specifies the interface type, location, and subinterface number. • Replace the *instance* argument with one of these instances: – Physical Ethernet interface instance, or with an Ethernet bundle instance. Naming notation is *rack*/*slot*/*module*/*port*, and a slash between values is required as part of the notation. – Ethernet bundle instance. Range is from 1 through 65535. • Replace the *subinterface* argument with the subinterface value. Range is from 0 through 4095. • Naming notation is *instance.subinterface*, and a period between arguments is required as part of the notation.
Step 3	**l2transport** **Example:** `RP/0/RSP0/CPU0:router(config-subif)#l2transport`	Enables Layer 2 transport mode on a port and enter Layer 2 transport configuration mode.
Step 4	**encapsulation dot1q** *vlan-id* **Example:** `RP/0/RSP0/CPU0:router(config-subif-l2)# encapsulation dot1q 100`	Assigns a VLAN Attachment Circuit to the subinterface. • Replace the vlan-id argument with a subinterface identifier. Range is from 1 to 4094 inclusive (0 and 4095 are reserved). To configure a basic Dot1Q Attachment Circuit, use this syntax: **encapsulation dot1q** *vlan-id* • To configure a QinQ Attachment Circuit, use this syntax: **encapsulation dot1q** *vlan-id* **second-dot1q** *vlan-id* **Note** Following are the varieties of **encapsulation** commands: – encapsulation dot1q 100 – encapsulation dot1q 100 second-dot1q 101 – encapsulation dot1ad 200 dot1q 201

	Command or Action	Purpose
Step 5	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config)# end` or `RP/0/RSP0/CPU0:router(config)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 6	**show ethernet trunk bundle-ether** ***instance*** **Example:** `RP/0/RSP0/CPU0:router# show ethernet trunk bundle-ether 5`	(Optional) Displays the interface configuration. The Ethernet bundle instance range is from 1 through 65535.

Configuring Native VLAN

This task explains how to configure a native VLAN on an interface.

SUMMARY STEPS

1. **configure**
2. **interface [GigabitEthernet | TenGigE | Bundle-Ether]** *instance.subinterface* **l2transport**
3. **encapsulation dot1q** <*vlan-id*>, **untagged**
4. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface** [**GigabitEthernet** | **TenGigE** | **Bundle-Ether**] *instance.subinterface* **l2transport** **Example:** `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/2/0/4.2 l2transport`	Enters subinterface configuration and specifies the interface type, location, and subinterface number. • Replace the instance argument with one of these instances: – Physical Ethernet interface instance, or with an Ethernet bundle instance. Naming notation is rack/slot/module/port, and a slash between values is required as part of the notation. – Ethernet bundle instance. Range is from 1 through 65535. • Replace the subinterface argument with the subinterface value. Range is from 0 through 4095. • Naming notation is instance.subinterface, and a period between arguments is required as part of the notation. **Note** You must include the l2transport keyword in the command string; otherwise, the configuration creates a Layer 3 subinterface rather than an Attachment Circuit.

	Command or Action	Purpose
Step 3	**encapsulation** [**dot1q** *vlan-id,* **untagged**] **Example:** `RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 400`	Defines the Native VLAN, associated with an 802.1Q trunk interface. • The *vlan-id* argument is the ID of the subinterface. • Range is from 1 through 4094 inclusive (0 and 4095 are reserved). It is possible to receive both dot1q 400 and untagged frames by issuing the **encapsulation** command with the **untagged** keyword.
Step 4	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-subif)# end` or `RP/0/RSP0/CPU0:router(config-subif)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Removing an 802.1Q VLAN Subinterface

This task explains how to remove 802.1Q VLAN subinterfaces that have been previously configured using the "Configuring 802.1Q VLAN Subinterfaces" task in this module.

SUMMARY STEPS

1. **configure**
2. **no interface** {**GigabitEthernet** | **TenGigE** | **Bundle-Ether**] *instance.subinterface*
3. Repeat Step 2 to remove other VLAN subinterfaces.
4. **end**
   or
   commit
5. **show ethernet trunk bundle-ether** *instance* (Optional)

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**no interface** [**GigabitEthernet** | **TenGigE** | **Bundle-Ether**] *instance.subinterface* **Example:** `RP/0/RSP0/CPU0:router(config)# no interface TenGigE 0/2/0/4.10`	Removes the subinterface, which also automatically deletes all the configuration applied to the subinterface. • Replace the *instance* argument with one of these instances: – Physical Ethernet interface instance, or with an Ethernet bundle instance. Naming notation is *rack*/*slot*/*module*/*port*, and a slash between values is required as part of the notation. – Ethernet bundle instance. Range is from 1 through 65535. • Replace the *subinterface* argument with the subinterface value. Range is from 0 through 4095. Naming notation is *instance.subinterface*, and a period between arguments is required as part of the notation.

	Command or Action	Purpose
Step 3	Repeat Step 2 to remove other VLAN subinterfaces.	—
Step 4	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config)# end` or `RP/0/RSP0/CPU0:router(config)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 5	**show ethernet trunk bundle-ether** *instance* **Example:** `RP/0/RSP0/CPU0:router# show ethernet trunk bundle-ether 5`	(Optional) Displays the interface configuration. The Ethernet bundle instance range is from 1 through 65535.

Configuration Examples

This section provides these configuration examples:

- Configuring an Ethernet Interface: Example
- Configuring a L2VPN AC: Example
- Configuring VPWS with Link Bundles: Example
- Configuring Ethernet Bundle with L2 and L3 Services: Example
- Configuring VLAN Subinterfaces: Example

Configuring an Ethernet Interface: Example

This example shows how to configure an interface for a 10-Gigabit Ethernet modular services card:

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface TenGigE 0/0/0/1
RP/0/RSP0/CPU0:router(config-if)# l2transport
RP/0/RSP0/CPU0:router(config-if)# mtu 1448
RP/0/RSP0/CPU0:router(config-if)# no shutdown
RP/0/RSP0/CPU0:router(config-if)# end
Uncommitted changes found, commit them? [yes]: yes

RP/0/RSP0/CPU0:router# show interfaces TenGigE 0/0/0/1

TenGigE0/0/0/1 is down, line protocol is down
  Hardware is TenGigE, address is 0001.2468.abcd (bia 0001.81a1.6b23)
  Internet address is 172.18.189.38/27
  MTU 1448 bytes, BW 10000000 Kbit
     reliability 0/255, txload Unknown, rxload Unknown
  Encapsulation ARPA,
  Full-duplex, 10000Mb/s, LR
  output flow control is on, input flow control is on
  loopback not set
  ARP type ARPA, ARP timeout 01:00:00
  Last clearing of "show interface" counters never
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 total input drops
     0 drops for unrecognized upper-level protocol
     Received 0 broadcast packets, 0 multicast packets
              0 runts, 0 giants, 0 throttles, 0 parity
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     0 packets output, 0 bytes, 0 total output drops
     Output 0 broadcast packets, 0 multicast packets
     0 output errors, 0 underruns, 0 applique, 0 resets
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
```

Configuring a L2VPN AC: Example

This example indicates how to configure a L2VPN AC on an Ethernet interface:

```
RP/0/RSP0/CPU0:router#configure
RP/0/RSP0/CPU0:router(config)#interface gigabitethernet 0/5/0/0.2 l2transport
RP/0/RSP0/CPU0:router(config-subif)#encapsulation dot1q 100
RP/0/RSP0/CPU0:router(config-subif)#ethernet egress-filter strict
RP/0/RSP0/CPU0:router(config-subif)#l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#clear

RP/0/RSP0/CPU0:router#configure
RP/0/RSP0/CPU0:router(config)#interface gigabitethernet 0/5/0/0.2 l2transport
RP/0/RSP0/CPU0:router(config-subif)#encapsulation dot1q 100
RP/0/RSP0/CPU0:router(config-subif)#ethernet egress-filter strict
RP/0/RSP0/CPU0:router(config-subif)#interface gigabitethernet 0/5/0/1.100 l2transport
RP/0/RSP0/CPU0:router(config-subif)#encapsulation dot1q 100
RP/0/RSP0/CPU0:router(config-subif)#ethernet egress-filter strict
RP/0/RSP0/CPU0:router(config-subif)#l2vpn
RP/0/RSP0/CPU0:router(config-l2vpn)#bridge group example
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#bridge-domain mybridge
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#interface gigabitethernet 0/5/0/0.2
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#interface gigabitethernet 0/5/0/1.100
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#exit
RP/0/RSP0/CPU0:router(config-l2vpn-bg)#exit
RP/0/RSP0/CPU0:router(config-l2vpn)#exit
RP/0/RSP0/CPU0:router(config)#show

Building configuration...
!! IOS XR Configuration 0.0.0
interface GigabitEthernet0/5/0/0.2 l2transport
 encapsulation dot1q 100
 ethernet egress-filter strict
!
interface GigabitEthernet0/5/0/1.100 l2transport
 encapsulation dot1q 100
 ethernet egress-filter strict
!
l2vpn
 bridge group example
  bridge-domain mybridge
   interface GigabitEthernet0/5/0/0.2
   !
   interface GigabitEthernet0/5/0/1.100
   !
  !
 !
end
```

Configuring VPWS with Link Bundles: Example

Physical Interfaces (Port mode)

```
interface Bundle-Ether12
 l2transport
!
interface GigabitEthernet0/1/0/10
 negotiation auto
 l2transport
!
interface GigabitEthernet0/1/0/20
 bundle id 12 mode on
 negotiation auto
!
interface GigabitEthernet0/1/0/21
 bundle id 12 mode on
 negotiation auto
!
 !
l2vpn
 xconnect group test
  p2p test
   interface Bundle-Ether12
   !
   interface GigabitEthernet0/1/0/10
   !
  !
 !
!
```

Sub Interfaces (EFP mode)

```
interface Bundle-Ether12
!
interface Bundle-Ether12.1 l2transport
  encapsulation dot1q 12
 !
!
interface GigabitEthernet0/1/0/10
 negotiation auto
!
interface GigabitEthernet0/1/0/10.1  l2transport
  encapsulation dot1q 12
 !

!
interface GigabitEthernet0/1/0/20
 bundle id 12 mode on
 negotiation auto
!
interface GigabitEthernet0/1/0/21
 bundle id 12 mode on
 negotiation auto
!
 !
l2vpn
```

```
 xconnect group test
  p2p test
   interface Bundle-Ether12.1
   !
   interface GigabitEthernet0/1/0/10.1
   !
  !
 !
!
```

Configuring Ethernet Bundle with L2 and L3 Services: Example

This example shows how to configure an Ethernet bundle interface with L3 services:

```
configure
interface Bundle-Ether 100
 ipv4 address 12.12.12.2 255.255.255.0

!
```

This example shows how to configure an Ethernet bundle subinterface with L3 services:

```
configure
interface Bundle-Ether 100.1
 ipv4 address 13.13.13.2 255.255.255.0

!
```

This example shows how to configure an Ethernet bundle interface with L2 services:

```
configure
 interface Bundle-Ether 101
 l2transport

!
```

This example shows how to configure an Ethernet bundle interface with L2 services:

```
configure
 interface Bundle-Ether1.1 l2transport
!
```

Configuring VLAN Subinterfaces: Example

This example shows how to create VLAN subinterfaces:

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface TenGigE 0/2/0/4.1 l2transport
RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 20
RP/0/RSP0/CPU0:router(config-subif)# interface TenGigE0/2/0/4.2 l2transport
RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 30
RP/0/RSP0/CPU0:router(config-subif)# interface TenGigE0/2/0/4.3 l2transport
RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 40
RP/0/RSP0/CPU0:router(config-subif)# commit
RP/0/RSP0/CPU0:router(config-subif)# exit
RP/0/RSP0/CPU0:router(config)# exit
```

This example shows how to create two VLAN subinterfaces on an Ethernet bundle at one time:

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface Bundle-Ether 1 l2transport
RP/0/RSP0/CPU0:router(config-if-l2)# exit
RP/0/RSP0/CPU0:router(config)# interface Bundle-Ether  1.1 l2transport
RP/0/RSP0/CPU0:router(config-subif-l2)#  encapsulation dot1q 10
RP/0/RSP0/CPU0:router(config-subif)# exit
RP/0/RSP0/CPU0:router(config)# interface Bundle-Ether 1.2 l2transport
RP/0/RSP0/CPU0:router(config-subif-l2)# encapsulation dot1q 20
RP/0/RSP0/CPU0:router(config-subif)# exit
```

This example shows how to create a basic Dot1Q Attachment Circuit:

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface TenGigE 0/2/0/4.1 l2transport
RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 20
RP/0/RSP0/CPU0:router(config-subif)# commit
RP/0/RSP0/CPU0:router(config-subif)# exit
RP/0/RSP0/CPU0:router(config)# exit
```

This example shows how to create a QinQ Attachment Circuit:

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface TenGigE 0/2/0/4.2 l2transport
RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 20 second-dot1q 10
RP/0/RSP0/CPU0:router(config-subif)# commit
RP/0/RSP0/CPU0:router(config-subif)# exit
RP/0/RSP0/CPU0:router(config)# exit
```

This example shows how to create a Q-in-Any Attachment Circuit:

```
RP/0/RSP/CPU0:router# configure
RP/0/RSP/CPU0:router(config)# interface TenGigE 0/2/0/4.3 l2transport
RP/0/RSP/CPU0:router(config-subif)# encapsulation dot1q 30 second-dot1q any
RP/0/RSP/CPU0:router(config-subif)# commit
RP/0/RSP/CPU0:router(config-subif)# exit
RP/0/RSP/CPU0:router(config)# exit
```

Where to Go Next

When you have configured an Ethernet interface, you can configure individual VLAN subinterfaces on that Ethernet interface. For information about configuring VLAN subinterfaces, see the The Cisco ASR 9000 Series Routers Carrier Ethernet Model module later in this document.

For information about IPv6 see the *Implementing Access Lists and Prefix Lists* module in the *Cisco ASR 9000 Series Aggregation Services Router IP Addresses and Services Debug Command Reference.*

Additional References

These sections provide references related to implementing Gigabit and 10-Gigabit Ethernet interfaces.

Related Documents

Related Topic	Document Title
Cisco IOS XR master command reference	*Cisco IOS XR Master Commands List*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
There are no applicable MIBs for this module.	To locate and download MIBs for selected platforms using Cisco IOS XR Software, use the Cisco MIB Locator found at this URL: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport

Ethernet Features

This module describes how to configure Layer 2 (L2) Ethernet features on the Cisco ASR 9000 Series Aggregation Services Routers supporting Cisco IOS XR software.

For more information on configuring Ethernet interfaces, refer to The Cisco ASR 9000 Series Routers Carrier Ethernet Model module of this configuration guide.

Feature History for Configuring Ethernet Interfaces on the Cisco ASR 9000 Series Routers

Release	Modification
Release 3.9.1	Support for Policy Based Forwarding and Layer 2 Protocol Tunneling features was added.

Contents

Prerequisites for Implementing Ethernet Features

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.

Information About Implementing Ethernet Features

To configure 10-Gigabit Ethernet interfaces, you must understand these concepts:

- Policy Based Forwarding, page 62
- Layer 2 Protocol Tunneling, page 62

Policy Based Forwarding

The Cisco ASR 9000 Series Routers allow a single MAC address to be mapped to a VLAN that is different from the port's configured VLAN. To separate the traffic entering two different EFPs, you must define an EFP using the source VLAN tag and the source MAC address.

Layer 2 Protocol Tunneling

Layer 2 Protocol Tunneling (L2PT) is a Cisco proprietary protocol for tunneling Ethernet protocol frames across Layer 2 (L2) switching domains.

When an L2 protocol frame enters the interface of an L2 switching device, the switch or router performs one of these actions on the frame:

- forward—the frame is switched or routed with no exceptional handling.
- drop—the frame is discarded on the router.
- terminate—the router recognizes that the frame is an L2 protocol frame, and therefore sends it to the router's control plane for protocol processing.
- tunnel—the router encapsulates the frame to hide its identity as a protocol frame. This prevents the frame from being terminated on other routers. The opposite end of the tunnel performs a decapsulation, returning the frame to its original state.

L2PT Features

The Cisco ASR 9000 Series Routers offer these functions:

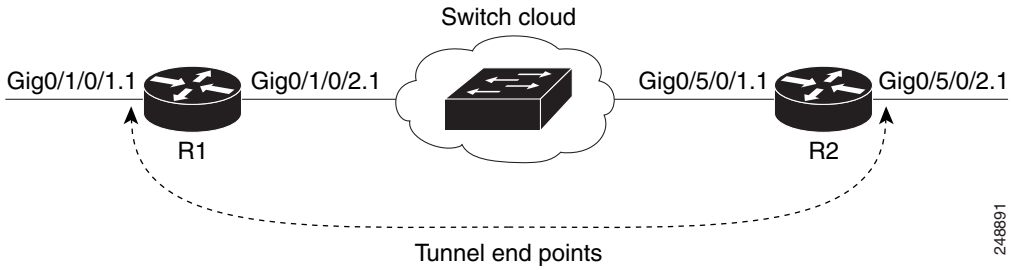
- Tunnels these protocols:
  - Cisco Discovery Protocol (CDP)
  - Spanning Tree Protocol (STP and its derivatives)
  - Virtual Trunking Protocol (VTP)
- Supports these modes of tunneling
  - Forward
  - Reverse
- L2PT encapsulates and decapsulates protocol frames that have VLAN headers.
- Supports capability of handling enormous frame rates. The Cisco ASR 9000 Series Routers perform L2PT encapsulation and decapsulation at the interface line rates.

Note There are no dedicated L2PT counters. There are no L2PT-specific adjustments for QoS or other miscellaneous parameters.

L2PT in the Forward Mode

Figure 1 shows L2PT configured in the forward mode.

Figure 1 L2PT in forward mode



A Service Provider network (S-network) is depicted in Figure 1. The customer network (C-network) connects to router R1 at the GigabitEthernet subinterface 0/1/0/1.1, and to router R2 at the GigabitEthernet subinterface 0/5/0/2.1. The C-network is not shown in the diagram; however, the C-network sends L2 traffic through the S-network, and the S-network switches the traffic from end to end. The customer traffic also carries L2 protocol frames. The purpose of L2PT is to allow these protocol frames to pass through the S-network. In forward mode, L2PT is applied to the customer facing interfaces of the S-network, R1 GigabitEthernet 0/1/0/1.1 and R2 GigabitEthernet 0/5/0/2.1.

Figure 1 depicts the configuration for L2PT in forward mode:

R1:

```
!
interface GigabitEthernet0/1/0/1
 negotiation auto
!
interface GigabitEthernet0/1/0/1.1 l2transport
 encapsulation default
 l2protocol cpsv tunnel
!
interface GigabitEthernet0/1/0/2
 negotiation auto
!
interface GigabitEthernet0/1/0/2.1 l2transport
 encapsulation default
!
l2vpn
 xconnect group examples
  p2p r1-connect
   interface GigabitEthernet0/1/0/1.1
   interface GigabitEthernet0/1/0/2.1
  !
 !
!
```

R2:

```
!
interface GigabitEthernet0/5/0/1
 negotiation auto
!
interface GigabitEthernet0/5/0/1.1 l2transport
 encapsulation default
!
interface GigabitEthernet0/5/0/2
 negotiation auto
!
interface GigabitEthernet0/5/0/2.1 l2transport
 encapsulation default
 l2protocol cpsv tunnel
!
l2vpn
 xconnect group examples
  p2p r2-connect
   interface GigabitEthernet0/5/0/1.1
   interface GigabitEthernet0/5/0/2.1
  !
 !
!
```

Protocol traffic enters router R1 at the GigabitEthernet subinterface 0/1/0/1.1. Router R1 detects the frames as protocol frames, and performs L2PT encapsulation at the customer facing interface. Inside R1, the local connection *r1-connect* connects R1's customer-facing and service provider-facing interfaces. The traffic then flows out of router R1 on GigabitEthernet subinterface 0/1/0/2.1 through several other service provider network routers or switches (switch cloud) into router R2 at GigabitEthernet subinterface 0/5/0/1.1. Router R2 connects the customer-facing and service provider-facing interfaces through a local connection *r2-connect*. Therefore, traffic is sent to the customer-facing interface GigabitEthernet 0/5/0/2.1. At this interface, an L2PT decapsulation occurs and the protocol traffic flows out of router R2 into the customer network.

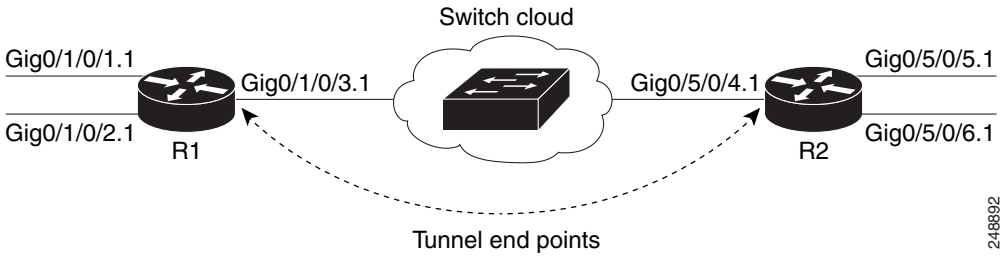
Without L2PT being configured the customer protocol frames that are sent into R1 are terminated. The customer traffic can consist of a variety of traffic; the protocol frames comprise a small percentage of the overall traffic stream.

L2PT in the Reverse Mode with Protocol Frame Tagging

The Cisco ASR 9000 Series Routers can perform L2PT encapsulation and decapsulation on supported L2 protocol frames that have VLAN headers. The L2 protocol frames do not have VLAN headers. However, in a service provider (SP) network that transports customer protocol traffic from one customer campus to another, this capability can be put to use within the SP network.

Figure 2 shows L2PT configured in the reverse mode. Assume that the customer traffic that enters R1 is trunked, that is all traffic is tagged. The only untagged traffic is the protocol traffic, that comes from the customer network.

Figure 2 L2PT in reverse mode



When L2PT is configured in the reverse mode, the L2PT encapsulation occurs when the frame exits the interface. Likewise, in reverse mode decapsulation is performed when the frame enters the interface. Therefore, the L2PT tunnel is formed between the service provider-facing interfaces, instead of the customer-facing interfaces.

In this example, once the protocol traffic enters router R1, a VLAN tag is added to it. Before the traffic is sent through the service provider network, a second VLAN tag is added (100). The Cisco ASR 9000 Series Routers perform the L2PT encapsulation on a double-tagged protocol frame.

Figure 2 shows four customer-facing interfaces (R1: GigabitEthernet subinterface 0/1/0.1.1, GigabitEthernet subinterface 0/1/0/2.1 and R2: GigabitEthernet subinterface 0/5/0/5.1, GigabitEthernet subinterface 0/5/0/6.1) and two service provider-facing interfaces (R1: GigabitEthernet subinterface 0/1/0/3.1 and R2: GigabitEthernet subinterface 0/5/0/4.1).

Figure 2 depicts the configuration for L2PT in reverse mode:

At R1:

```
!
interface GigabitEthernet0/1/0/1
 negotiation auto
!
interface GigabitEthernet0/1/0/1.1 l2transport
 encapsulation untagged
 rewrite ingress tag push dot1q 100 symmetric
 ethernet egress-filter strict
!
interface GigabitEthernet0/1/0/2
 negotiation auto
!
interface GigabitEthernet0/1/0/2.1 l2transport
 encapsulation untagged
 rewrite ingress tag push dot1q 200 symmetric
 ethernet egress-filter strict
!
interface GigabitEthernet0/1/0/3
 negotiation auto
!
interface GigabitEthernet0/1/0/3.1 l2transport
 encapsulation dot1q 500
 rewrite ingress tag pop 1 symmetric
 l2protocol cpsv reverse-tunnel
 ethernet egress-filter strict
!
l2vpn
 bridge group examples
  bridge-domain r1-bridge
   interface GigabitEthernet0/1/0/1.1
   !
   interface GigabitEthernet0/1/0/2.1
```

```
   !
   interface GigabitEthernet0/1/0/3.1
   !
  !
 !
!
```

At R2:

```
!
interface GigabitEthernet0/5/0/4
 negotiation auto
!
interface GigabitEthernet0/5/0/4.1 l2transport
 encapsulation dot1q 500
 rewrite ingress tag pop 1 symmetric
 l2protocol cpsv reverse-tunnel
 ethernet egress-filter strict
!
interface GigabitEthernet0/5/0/5
 negotiation auto
!
interface GigabitEthernet0/5/0/5.1 l2transport
 encapsulation untagged
 rewrite ingress tag push dot1q 100 symmetric
 ethernet egress-filter strict
!
interface GigabitEthernet0/5/0/6
 negotiation auto
!
interface GigabitEthernet0/5/0/6.1 l2transport
 encapsulation untagged
 rewrite ingress tag push dot1q 200 symmetric
 ethernet egress-filter strict
!
l2vpn
 bridge group examples
  bridge-domain r2-bridge
   interface GigabitEthernet0/5/0/4.1
   !
   interface GigabitEthernet0/5/0/5.1
   !
   interface GigabitEthernet0/5/0/6.1
   !
  !
 !
!
```

These assumptions are made:

- Customer traffic entering router R1 is trunked, that is all traffic is tagged. The only untagged traffic is the protocol traffic, which arrives from the customer network.
- The Customer-facing interfaces GigabitEthernet 0/1/0/1 at router R1 and Gigabit Ethernet 0/5/0/5 at router R2 belong to the same customer. Customer-facing interfaces GigabitEthernet 0/1/0/2 at router R1 and GigabitEthernet 0/5/0/6 at router R2 belong to a different customer.
- Traffic from different customers remain segregated.
- Only L2 protocol traffic is sent through the customer-facing interfaces.
- L2 protocol traffic entering the customer-facing interfaces is untagged.
- Traffic must be L2PT encapsulated to successfully pass through the switch cloud.

The purpose of this topology is that router R1 and R2 must receive customer protocol traffic from multiple customer interfaces, and multiplex the traffic across a single service provider interface and link. At the decapsulation end, the reverse is performed. Traffic entering router R1 on the GigabitEthernet subinterface 0/1/0/1.1 exits router R2 from the GigabitEthernet subinterface 0/5/0/5.1 only while traffic entering router R1 at GigabitEthernet subinterface 0/1/0/2.1 exits router R2 from GigabitEthernet subinterface 0/5/0/6.1 only.

A protocol frame entering router R1 on GigabitEthernet interface 0/1/0/1 travels through the network in this manner:

- The protocol frame is directed to GigabitEthernet subinterface 0/1/0/1.1, as the frame is untagged.
- The rewrite statement with GigabitEthernet subinterface 0/1/0/1.1 causes a tag of ID 100 to be added to the frame.
- The frame enters router R1's bridge domain r1-bridge.
- The bridge (r1-bridge) floods the frame to all attachment circuits (AC) on the bridge domain, except the originating AC (split horizon AC).
- Ethernet egress filtering on GigabitEthernet subinterface 0/1/0/2.1 detects a tag ID mismatch, and drops the frame. In this way, the bridge domain's flooded traffic is prevented from exiting other customer interfaces.
- A flooded copy of the frame is sent to GigabitEthernet subinterface 0/1/0/3.1.
- GigabitEthernet subinterface 0/1/0/3.1 adds a second tag.
- The frame receives an L2PT encapsulation by GigabitEthernet subinterface 0/1/0/3.1 before it leaves router R1 through the GigabitEthernet interface 0/1/0/3.

Note The frame is now double-tagged (100 inner, 500 outer) and has the L2PT MAC DA.

- The frame passes to router R2 GigabitEthernet interface 0/5/0/4 because of the L2PT encapsulation.
- The frame after having entered router R2 on GigabitEthernet interface 0/5/0/4 is directed to GigabitEthernet subinterface 0/5/0/4.1.
- On entering GigabitEthernet subinterface 0/5/0/4.1, an L2PT decapsulation operation is performed on the frame.
- The outer tag ID 500 is removed by GigabitEthernet subinterface 0/5/0/4.1
- Router R2's bridge (r2-bridge) floods the frames to all ACs.
- Ethernet egress filtering drops the frames on all ACs except the AC through which the frame exits.
- As the frame exits router R2 from GigabitEthernet subinterface 0/5/0/5.1, the tag of ID 100 is removed.
- The frame that exits router R2 from GigabitEthernet interface 0/5/0/5 is identical to the original frame that entered router R1 through GigabitEthernet interface 0/1/0/1.

L2PT Configuration Notes

Keep these points in mind while configuring L2PT:

- The **l2protocol** command can be configured on either a main or L2 subinterface.
- The **l2protocol** command can be configured on physical or bundle interfaces.
- When the **l2protocol** and **ethernet filtering** commands are configured on the same interface, L2PT encapsulation occurs before ethernet filtering. This means that L2PT prevents the CDP, STP, and VTP protocol frames from being dropped by ethernet filtering.
- When L2PT is configured with other interface features, L2PT encapsulation occurs before the processing for other interface features.
- L2PT encapsulation and decapsulation is supported for untagged protocol frames, single-tagged, and double-tagged frames. Tag Ethertypes of 0x8100, 0x88A8, and 0x9100 are supported, however, 0x9200 is not.

How to Implement Ethernet Features

These tasks are described in this section:

Note For information on configuring Ethernet interfaces, refer to the *Cisco ASR 9000 Series Aggregation Services Router Interface and Hardware Component Configuration Guide.*

Configuring Policy Based Forwarding

This section contains These procedures:

Enabling Policy Based Forwarding

Perform this task to enable policy based forwarding.

SUMMARY STEPS

1. **configure**
2. **interface** *type interface-path-id.subinterface* **l2transport**
3. **encapsulation dot1q** *vlan-id* **ingress source-mac** *mac-address*
   or
   encapsulation dot1ad *vlan-id* **ingress source-mac** *mac-address*
   or
   encapsulation untagged ingress source-mac *mac-address*
   or
   encapsulation dot1ad *vlan-id* **dot1q** *vlan-id* **ingress source-mac** *mac-address*
   or
   encapsulation dot1q *vlan-id* **second-dot1q** *vlan-id* **ingress source-mac** *mac-address*
4. **rewrite ingress tag translate 1-to-1 dot1q** *vlan-id* **symmetric**
   or
   rewrite ingress tag push dot1q *vlan-id* **symmetric**
5. **ethernet egress-filter strict**
6. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface** *type interface-path-id.subinterface* **l2transport** **Example:** `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/2/0/4.10 l2transport`	Enters subinterface configuration mode and enables Layer 2 transport mode on a port and enters Layer 2 transport configuration mode.
Step 3	**encapsulation dot1q** *vlan-id* **ingress source-mac** *mac-address* or **encapsulation dot1ad** *vlan-id* **ingress source-mac** *mac-address* or **encapsulation untagged ingress source-mac** *mac-address* or **encapsulation dot1ad** *vlan-id* **dot1q** *vlan-id* **ingress source-mac** *mac-address* or **encapsulation dot1q** *vlan-id* **second-dot1q** *vlan-id* **ingress source-mac** *mac-address* **Example:** `RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 10 ingress source-mac 0.1.2` or `RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1ad 10 ingress source-mac 0.1.4` or `RP/0/RSP0/CPU0:router(config-subif)# encapsulation untagged ingress source-mac 0.1.3` or `RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1ad 10 dot1q 10 ingress source-mac 0.1.2` or `RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 10 second-dot1q 20 ingress source-mac 0.1.2`	Assigns the matching VLAN ID and Ethertype to the interface.

	Command or Action	Purpose
Step 4	**rewrite ingress tag translate 1-to-1 dot1q** *vlan-id* **symmetric** or **rewrite ingress tag push dot1q** *vlan-id* **symmetric** Example: RP/0/RSP0/CPU0:router(config-subif)# rewrite ingress tag translate 1-to-1 dot1q 100 symmetric or rewrite ingress tag push dot1q 101 symmetric	Specifies the encapsulation adjustment that is to be performed on the frame ingress to the service instance.
Step 5	**ethernet egress-filter strict** Example: RP/0/RSP0/CPU0:router(config-subif)# ethernet egress-filter strict	Enables strict egress filtering on all subinterfaces.
Step 6	**end** or **commit** **Example:** RP/0/RSP0/CPU0:router(config-subif)# end or RP/0/RSP0/CPU0:router(config-subif)# commit	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Source Bypass Filter

Perform this task to add a source bypass filter.

SUMMARY STEPS

1. **configure**
2. **interface** *type interface-path-id.subinterface* **l2transport**
3. **encapsulation dot1q** *vlan-id*
   or
   encapsulation dot1ad *vlan-id*
   or
   encapsulation untagged
   or
   encapsulation dot1ad *vlan-id* **dot1q** *vlan-id*
   or
   encapsulation dot1q *vlan-id* **second-dot1q** *vlan-id*
4. **rewrite ingress tag translate 1-to-1 dot1q** *vlan-id* **symmetric**
5. **ethernet egress-filter disable**
6. **ethernet source bypass egress-filter**
7. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface** *type interface-path-id.subinterface* **l2transport** **Example:** `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/2/0/4.1 l2transport`	Enters subinterface configuration mode and enables Layer 2 transport mode on a port and enters Layer 2 transport configuration mode.

	Command or Action	Purpose
Step 3	**encapsulation dot1q** *vlan-id* or **encapsulation dot1ad** *vlan-id* or **encapsulation untagged** or **encapsulation dot1ad** *vlan-id* **dot1q** *vlan-id* or **encapsulation dot1q** *vlan-id* **second-dot1q** *vlan-id* **Example:** RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 10 or RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1ad 10 or RP/0/RSP0/CPU0:router(config-subif)# encapsulation untagged or RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1ad 10 dot1q 10 or RP/0/RSP0/CPU0:router(config-subif)# encapsulation dot1q 10 second-dot1q 20	Assigns the matching VLAN ID and Ethertype to the interface.
Step 4	**rewrite ingress tag translate 1-to-1 dot1q** *vlan-id* **symmetric** Example: RP/0/RSP0/CPU0:router(config-subif)# rewrite ingress tag translate 1-to-1 dot1q 100 symmetric	Specifies the encapsulation adjustment that is to be performed on the frame ingress to the service instance.
Step 5	**ethernet egress-filter disable** Example: RP/0/RSP0/CPU0:router(config-subif)# ethernet egress-filter strict	Disables egress filtering on all subinterfaces.

	Command or Action	Purpose
Step 6	**ethernet source bypass egress-filter** Example: `RP/0/RSP0/CPU0:router(config-subif)# ethernet source bypass egress-filter`	Enables source bypass egress filtering on the subinterfaces.
Step 7	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-subif)# end` or `RP/0/RSP0/CPU0:router(config-subif)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuration Examples

This section provides these configuration examples:

- Configuring Policy Based Forwarding: Example
- Configuring Layer 2 Protocol Tunneling: Example

Configuring Policy Based Forwarding: Example

This example shows how to configure policy based forwarding:

```
config
 interface GigabitEthernet0/0/0/2.3 l2transport
 encapsulation dot1q 10 ingress source-mac 0000.1111.2222
 rewrite ingress tag translate 1-to-1 dot1q 100 symmetric
 ethernet egress-filter strict
!
interface GigabitEthernet0/0/0/2.4 l2transport
 encapsulation untagged ingress source-mac 0000.1111.3333
 rewrite ingress tag push dot1q 101 symmetric
 ethernet egress-filter strict
!

interface GigabitEthernet0/0/0/0/3.1 l2transport
 encapsulation dot1q 1
 rewrite ingress tag translate 1-to-1 dot1q 4094 symmetric
 ethernet egress-filter disabled
 ethernet source-bypass-egress-filter
!
```

Configuring Layer 2 Protocol Tunneling: Example

This section includes configuration examples for L2PT in the forward and reverse modes.

Configuring L2PT in forward mode

This example shows how to configure L2PT in the forward mode:

At the customer facing router (encapsulation end):

```
!
interface GigabitEthernet0/1/0/1
 negotiation auto
!
interface GigabitEthernet0/1/0/1.1 l2transport
 encapsulation default
 l2protocol cpsv tunnel
!
interface GigabitEthernet0/1/0/2
 negotiation auto
!
interface GigabitEthernet0/1/0/2.1 l2transport
 encapsulation default
!
l2vpn
 xconnect group examples
```

```
  p2p r1-connect
   interface GigabitEthernet0/1/0/1.1
   interface GigabitEthernet0/1/0/2.1
  !
 !
!
```

At the customer facing router (decapsulation end):

```
!
interface GigabitEthernet0/5/0/1
 negotiation auto
!
interface GigabitEthernet0/5/0/1.1 l2transport
 encapsulation default
!
interface GigabitEthernet0/5/0/2
 negotiation auto
!
interface GigabitEthernet0/5/0/2.1 l2transport
 encapsulation default
 l2protocol cpsv tunnel
!
l2vpn
 xconnect group examples
  p2p r2-connect
   interface GigabitEthernet0/5/0/1.1
   interface GigabitEthernet0/5/0/2.1
  !
 !
!
```

Configuring L2PT in reverse mode

This example shows how to configure L2PT in the reverse mode:

At the customer facing router (encapsulation end):

```
!
interface GigabitEthernet0/1/0/1
 negotiation auto
!
interface GigabitEthernet0/1/0/1.1 l2transport
 encapsulation untagged
 rewrite ingress tag push dot1q 100 symmetric
 ethernet egress-filter strict
!
interface GigabitEthernet0/1/0/2
 negotiation auto
!
interface GigabitEthernet0/1/0/2.1 l2transport
 encapsulation untagged
 rewrite ingress tag push dot1q 200 symmetric
 ethernet egress-filter strict
!
interface GigabitEthernet0/1/0/3
 negotiation auto
!
```

```
interface GigabitEthernet0/1/0/3.1 l2transport
 encapsulation dot1q 500
 rewrite ingress tag pop 1 symmetric
 l2protocol cpsv reverse-tunnel
 ethernet egress-filter strict
!
l2vpn
 bridge group examples
  bridge-domain r1-bridge
   interface GigabitEthernet0/1/0/1.1
   !
   interface GigabitEthernet0/1/0/2.1
   !
   interface GigabitEthernet0/1/0/3.1
   !
  !
 !
!
```

At the customer facing router (decapsulation end):

```
!
interface GigabitEthernet0/5/0/4
 negotiation auto
!
interface GigabitEthernet0/5/0/4.1 l2transport
 encapsulation dot1q 500
 rewrite ingress tag pop 1 symmetric
 l2protocol cpsv reverse-tunnel
 ethernet egress-filter strict
!
interface GigabitEthernet0/5/0/5
 negotiation auto
!
interface GigabitEthernet0/5/0/5.1 l2transport
 encapsulation untagged
 rewrite ingress tag push dot1q 100 symmetric
 ethernet egress-filter strict
!
interface GigabitEthernet0/5/0/6
 negotiation auto
!
interface GigabitEthernet0/5/0/6.1 l2transport
 encapsulation untagged
 rewrite ingress tag push dot1q 200 symmetric
 ethernet egress-filter strict
!
l2vpn
 bridge group examples
  bridge-domain r2-bridge
   interface GigabitEthernet0/5/0/4.1
   !
   interface GigabitEthernet0/5/0/5.1
   !
   interface GigabitEthernet0/5/0/6.1
   !
  !
 !
!
```

Additional References

These sections provide references related to implementing Gigabit and 10-Gigabit Ethernet interfaces.

Related Documents

Related Topic	Document Title
Cisco IOS XR master command reference	*Cisco IOS XR Master Commands List*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
There are no applicable MIBs for this module.	To locate and download MIBs for selected platforms using Cisco IOS XR Software, use the Cisco MIB Locator found at this URL: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport

Configuring Link Bundles

On the Cisco ASR 9000 Series Aggregation Services Routers, a bundle is a group of one or more ports that are aggregated together and treated as a single link. The different links within a single bundle can have varying speeds, where the fastest link can be a maximum of four times greater than the slowest link. Each bundle has a single MAC, a single IP address, and a single configuration set (such as ACLs or QoS).

The Cisco ASR 9000 Series Routers supports bundling for these types of interfaces:

- Ethernet interfaces
- VLAN subinterfaces

Note Bundles do not have a one-to-one modular services card association.

Feature History for Configuring Link Bundling on Cisco IOS XR Software

Release	Modification
Release 3.7.2	This feature was introduced on the Cisco ASR 9000 Series Routers.

Contents

This chapter includes these sections:

Prerequisites for Configuring Link Bundles

Before configuring Link Bundling, be sure 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.
- You know the interface IP address.
- You know which links should be included in the bundle you are configuring.
- If you are configuring an Ethernet link bundle, you have at least one of these Ethernet line cards installed in the router:
  - 2-port 10-Gigabit Ethernet line card
  - 4-port 10-Gigabit Ethernet line card
  - 8-port 10-Gigabit Ethernet line card
  - 16-port 10-Gigabit Ethernet line card
  - 20-port Gigabit Ethernet line card
  - 40-port Gigabit Ethernet line card

Note For more information about physical interfaces, PLIMs, and modular services cards, refer to the *Cisco ASR 9000 Series Routers Hardware Installation Guide*.

Information About Configuring Link Bundles

To implement the Link Bundling feature, you must understand these concepts:

Link Bundling Overview

A link bundle is simply a group of ports that are bundled together and act as a single link. The advantages of link bundles are these:

- Multiple links can span several line cards to form a single interface. Thus, the failure of a single link does not cause a loss of connectivity.
- Bundled interfaces increase bandwidth availability, because traffic is forwarded over all available members of the bundle. Therefore, traffic can flow on the available links if one of the links within a bundle fails. Bandwidth can be added without interrupting packet flow.

Although the individual links within a single bundle can have varying speeds, all links within a bundle must be of the same type.

Cisco IOS XR software supports these methods of forming bundles of Ethernet interfaces:

- IEEE 802.3ad—Standard technology that employs a Link Aggregation Control Protocol (LACP) to ensure that all the member links in a bundle are compatible. Links that are incompatible or have failed are automatically removed from a bundle.
- EtherChannel—Cisco proprietary technology that allows the user to configure links to join a bundle, but has no mechanisms to check whether the links in a bundle are compatible.

Characteristics of Cisco ASR 9000 Series Routers Link Bundles

This list describes the properties and limitations of link bundles on Cisco ASR 9000 Series Routerss:

- Any type of Ethernet interfaces can be bundled, with or without the use of LACP (Link Aggregation Control Protocol).
- Bundle membership can span across several line cards that are installed in a single router.
- A single bundle supports maximum of 64 physical links.
- A single Cisco ASR 9000 Series Routers supports a maximum of 128 bundles.
- Different link speeds are allowed within a single bundle, with a maximum of four times the speed difference between the members of the bundle.
- Physical layer and link layer configuration are performed on individual member links of a bundle.
- Configuration of network layer protocols and higher layer applications is performed on the bundle itself.
- A bundle can be administratively enabled or disabled.
- Each individual link within a bundle can be administratively enabled or disabled.
- Ethernet link bundles are created in the same way as Ethernet channels, where the user enters the same configuration on both end systems.
- The MAC address that is set on the bundle becomes the MAC address of the links within that bundle.
- When LACP configured, each link within a bundle can be configured to allow different keepalive periods on different members.
- Load balancing (the distribution of data between member links) is done by flow instead of by packet. Data is distributed to a link in proportion to the bandwidth of the link in relation to its bundle.
- QoS is supported and is applied proportionally on each bundle member.
- Link layer protocols, such as CDP and HDLC keepalives, work independently on each link within a bundle.

- Upper layer protocols, such as routing updates and hellos, are sent over any member link of an interface bundle.
- Bundled interfaces are point to point.
- A link must be in the up state before it can be in distributing state in a bundle.
- All links within a single bundle must be configured either to run 802.3ad (LACP) or Etherchannel (non-LACP). Mixed links within a single bundle are not supported.
- A bundle interface can contain physical links and VLAN subinterfaces only.
- Access Control List (ACL) configuration on link bundles is identical to ACL configuration on regular interfaces.
- Multicast traffic is load balanced over the members of a bundle. For a given flow, internal processes select the member link and all traffic for that flow is sent over that member.

Link Aggregation Through LACP

Aggregating interfaces on different modular services cards provides redundancy, allowing traffic to be quickly redirected to other member links when an interface or modular services card failure occurs.

The optional Link Aggregation Control Protocol (LACP) is defined in the IEEE 802 standard. LACP communicates between two directly connected systems (or peers) to verify the compatibility of bundle members. For the Cisco ASR 9000 Series Routers, the peer can be either another router or a switch. LACP monitors the operational state of link bundles to ensure these:

- All links terminate on the same two systems.
- Both systems consider the links to be part of the same bundle.
- All links have the appropriate settings on the peer.

LACP transmits frames containing the local port state and the local view of the partner system's state. These frames are analyzed to ensure both systems are in agreement.

IEEE 802.3ad Standard

The IEEE 802.3ad standard typically defines a method of forming Ethernet link bundles.

For each link configured as bundle member, this information is exchanged between the systems that host each end of the link bundle:

- A globally unique local system identifier
- An identifier (operational key) for the bundle of which the link is a member
- An identifier (port ID) for the link
- The current aggregation status of the link

This information is used to form the link aggregation group identifier (LAG ID). Links that share a common LAG ID can be aggregated. Individual links have unique LAG IDs.

The system identifier distinguishes one router from another, and its uniqueness is guaranteed through the use of a MAC address from the system. The bundle and link identifiers have significance only to the router assigning them, which must guarantee that no two links have the same identifier, and that no two bundles have the same identifier.

The information from the peer system is combined with the information from the local system to determine the compatibility of the links configured to be members of a bundle.

Bundle MAC addresses in the Cisco ASR 9000 Series Routers come from a set of reserved MAC addresses in the backplane.This MAC address stays with the bundle as long as the bundle interface exists. The bundle uses this MAC address until the user configures a different MAC address. The bundle MAC address is used by all member links when passing bundle traffic. Any unicast or multicast addresses set on the bundle are also set on all the member links.

Note We recommend that you avoid modifying the MAC address, because changes in the MAC address can affect packet forwarding.

QoS and Link Bundling

On the ingress direction, QoS is applied to the local instance of a bundle. Each bundle is associated with a set of queues. QoS is applied to the various network layer protocols that are configured on the bundle.

On the egress direction, QoS is applied on the bundle with a reference to the member links. QoS is applied based on the sum of the member bandwidths.

When QoS is applied on the bundle for either the ingress or egress direction, QoS is applied at each member interface.

The Link Bundling feature supports all the QoS features described in the *Cisco ASR 9000 Series Aggregation Services Router Modular Quality of Service Configuration Guide*.

The Link Bundling feature supports these QoS features:

- hi priority /lo priority—Maximum bandwidth is calculated as a percentage of the bundle interface bandwidth. This percentage is then applied to every member link on the egress, or to the local bundle instance on ingress.
- guaranteed bandwidth—Provided in percentage and applied to every member link.
- traffic shaping—Provided in percentage and applied to every member link.
- WRED—Minimum and maximum parameters are converted to the right proportion per member link or bundle instance, and then are applied to the bundle.
- marking—Process of changing the packet QoS level according to a policy.
- tail drop— Packets are dropped when the queue is full.

VLANs on an Ethernet Link Bundle

802.1Q VLAN subinterfaces can be configured on 802.3ad Ethernet link bundles. Keep this information in mind when adding VLANs on an Ethernet link bundle:

- The maximum number of VLANs allowed per bundle is 4000.
- The maximum number of bundled VLANs allowed per router is 16000.

Note The memory requirement for bundle VLANs is slightly higher than standard physical interfaces.

To create a VLAN subinterface on a bundle, include the VLAN subinterface instance with the **interface Bundle-Ether** command:

interface Bundle-Ether *instance.subinterface*

After you create a VLAN on an Ethernet link bundle, all physical VLAN subinterface configuration is supported on that link bundle.

Link Bundle Configuration Overview

These steps provide a general overview of the link bundle configuration process. Keep in mind that a link must be cleared of all previous network layer configuration before it can be added to a bundle:

1. In global configuration mode, create a link bundle. To create an Ethernet link bundle, enter the **interface Bundle-Ether** command.
2. Assign an IP address and subnet mask to the virtual interface using the **ipv4 address** command.
3. Add interfaces to the bundle you created in Step 1 with the **bundle id** command in the interface configuration submode. You can add up to 32 links to a single bundle.

Note A link is configured to be a member of a bundle from the interface configuration submode for that link.

Nonstop Forwarding During Card Failover

Cisco IOS XR software supports nonstop forwarding during failover between active and standby paired RSP cards. Nonstop forwarding ensures that there is no change in the state of the link bundles when a failover occurs.

For example, if an active RSP fails, the standby RSP becomes operational. The configuration, node state, and checkpoint data of the failed RSP are replicated to the standby RSP. The bundled interfaces will all be present when the standby RSP becomes the active RSP.

Note Failover is always onto the standby RSP.

Note You do not need to configure anything to guarantee that the standby interface configurations are maintained.

Link Failover

When one member link in a bundle fails, traffic is redirected to the remaining operational member links and traffic flow remains uninterrupted.

Bundle Interfaces: Redundancy, Load Sharing, Aggregation

On the Cisco ASR 9000 Series Aggregation Services Routers, a bundle is a group of one or more ports that are aggregated together and treated as a single link. The different links within a single bundle can have varying speeds, where the fastest link can be a maximum of four times greater than the slowest link. Each bundle has a single MAC, a single IP address, and a single configuration set (such as ACLs or QoS).

The Cisco ASR 9000 Series Routers supports bundling for these types of interfaces:

- Ethernet interfaces
- VLAN subinterfaces

How to Configure Link Bundling

This section contains these procedures:

Configuring Ethernet Link Bundles

This section describes how to configure a Ethernet link bundle.

Note MAC accounting is not supported on Ethernet link bundles.

Note In order for an Ethernet bundle to be active, you must perform the same configuration on both connection endpoints of the bundle.

SUMMARY STEPS

The creation of an Ethernet link bundle involves creating a bundle and adding member interfaces to that bundle, as shown in the steps that follow.

1. **configure**
2. **interface Bundle-Ether** *bundle-id*
3. **ipv4 address** *ipv4-address mask*
4. **bundle minimum-active bandwidth** *kbps* (Optional)
5. **bundle minimum-active links** *links* (Optional)
6. **bundle maximum-active links** *links* (Optional)
7. **bundle maximum-active links** *links* **hot-standby** (Optional)
8. **exit**
9. **interface** {**GigabitEthernet** | **TenGigE**} *instance*
10. **bundle id** *bundle-id* [**mode** {**active** | **on** | **passive**}
11. **no shutdown**
12. **exit**
13. Repeat Step 8 through Step 11 to add more links to the bundle you created in Step 2.
14. **end**
    or
    commit
15. **exit**
16. **exit**
17. Perform Step 1 through Step 15 on the remote end of the connection.
18. **show bundle Bundle-Ether** *bundle-id* [**reasons**]
19. **show lacp Bundle-Ether** *bundle-id*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface Bundle-Ether** *bundle-id* **Example:** `RP/0/RSP0/CPU0:router#(config)# interface Bundle-Ether 3`	Creates and names a new Ethernet link bundle. This **interface Bundle-Ether** command enters you into the interface configuration submode, where you can enter interface specific configuration commands are entered. Use the **exit** command to exit from the interface configuration submode back to the normal global configuration mode.
Step 3	**ipv4 address** *ipv4-address mask* **Example:** `RP/0/RSP0/CPU0:router(config-if)# ipv4 address 10.1.2.3 255.0.0.0`	Assigns an IP address and subnet mask to the virtual interface using the **ipv4 address** configuration subcommand.
Step 4	**bundle minimum-active bandwidth** *kbps* **Example:** `RP/0/RSP0/CPU0:router(config-if)# bundle minimum-active bandwidth 580000`	(Optional) Sets the minimum amount of bandwidth required before a user can bring up a bundle.
Step 5	**bundle minimum-active links** *links* **Example:** `RP/0/RSP0/CPU0:router(config-if)# bundle minimum-active links 2`	(Optional) Sets the number of active links required before you can bring up a specific bundle.
Step 6	**bundle maximum-active links** *links* **Example:** `RP/0/RSP0/CPU0:router(config-if)# bundle maximum-active links 1`	(Optional) Designates one active link and one link in standby mode that can take over immediately for a bundle if the active link fails (1:1 protection). The default number of active links allowed in a single bundle is 8. **Note** If the **bundle maximum-active** command is issued, then only the highest-priority link within the bundle is active. The priority is based on the value from the **bundle port-priority** command, where a lower value is a higher priority. Therefore, we recommend that you configure a higher priority on the link that you want to be the active link.

	Command or Action	Purpose
Step 7	**bundle maximum-active links links hot-standby** **Example:** `RP/0/RSP0/CPU0:router(config-if)# bundle maximum-active links 1 hot-standby`	The **hot-standby** keyword helps to avoid bundle flaps on a switchover or switchback event during which the bundle temporarily falls below the minimum links or bandwidth threshold. It sets default values for the wait-while timer and suppress-flaps timer to achieve this.
Step 8	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-if)# exit`	Exits interface configuration submode for the Ethernet link bundle.
Step 9	**interface** {**GigabitEthernet** | **TenGigE**} *instance* **Example:** `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 1/0/0/0`	Enters the interface configuration mode for the specified interface. Enter the **GigabitEthernet** or **TenGigE** keyword to specify the interface type. Replace the *instance* argument with the node-id in the *rack*/*slot*/*module* format. Mixed bandwidth bundle member configuration is only supported when 1:1 redundancy is configured (this means that a 1 GigabitEthernet member can only be configured as the backup of the 10 GigabitEthernet interface.) **Note** Mixed link bundle mode is supported only when active-standby operation is configured (usually with the lower speed link in standby mode).
Step 10	**bundle id** *bundle-id* [**mode** {**active** | **on** | **passive**}] **Example:** `RP/0/RSP0/CPU0:router(config-if)# bundle-id 3`	Adds the link to the specified bundle. To enable active or passive LACP on the bundle, include the optional **mode active** or **mode passive** keywords in the command string. To add the link to the bundle without LACP support, include the optional **mode on** keywords with the command string. **Note** If you do not specify the **mode** keyword, the default mode is **on (**LACP is not run over the port).
Step 11	**no shutdown** **Example:** `RP/0/RSP0/CPU0:router(config-if)# no shutdown`	(Optional) If a link is in the down state, bring it up. The **no shutdown** command returns the link to an up or down state depending on the configuration and state of the link.
Step 12	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-if)# exit`	Exits interface configuration submode for the Ethernet interface.

	Command or Action	Purpose
Step 13	(Optional) Repeat Step 8 through Step 11 to add more links to the bundle.	—
Step 14	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-if)# end` or `RP/0/RSP0/CPU0:router(config-if)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 15	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-if)# exit`	Exits interface configuration mode.
Step 16	**exit** **Example:** `RP/0/RSP0/CPU0:router(config)# exit`	Exits global configuration mode.
Step 17	Perform Step 1 through Step 15 on the remote end of the connection.	Brings up the other end of the link bundle.
Step 18	**show bundle Bundle-Ether** *bundle-id* [**reasons**] **Example:** `RP/0/RSP0/CPU0:router# show bundle Bundle-Ether 3 reasons`	(Optional) Shows information about the specified Ethernet link bundle.
Step 19	**show lacp Bundle-Ether** *bundle-id* **Example:** `RP/0/RSP0/CPU0:router# show lacp Bundle-Ether 3`	(Optional) Shows detailed information about LACP ports and their peers.

Configuring VLAN Bundles

This section describes how to configure a VLAN bundle. The creation of a VLAN bundle involves three main tasks:

1. Create an Ethernet bundle.
2. Create VLAN subinterfaces and assign them to the Ethernet bundle.
3. Assign Ethernet links to the Ethernet bundle.

These tasks are describe in detail in the procedure that follows.

Note In order for a VLAN bundle to be active, you must perform the same configuration on both ends of the bundle connection.

SUMMARY STEPS

The creation of a VLAN link bundle is described in the steps that follow.

1. **configure**
2. **interface Bundle-Ether** *bundle-id*
3. **ipv4 address** *ipv4-address mask*
4. **bundle minimum-active bandwidth** *kbps* (Optional)
5. **bundle minimum-active links** *links* (Optional)
6. **bundle maximum-active links** *links* (Optional)
7. **exit**
8. **interface Bundle-Ether** *bundle-id.vlan-id*
9. **encapsulation dot1q** *vlan-id*
10. **ipv4 address** *ipv4-address mask*
11. **no shutdown**
12. **exit**
13. Repeat Step 7 through Step 12 to add more VLANs to the bundle you created in Step 2.
14. **end**
    or
    commit
15. **exit**
16. **exit**
17. **show ethernet trunk bundle-Ether** *instance*
18. **configure**
19. **interface** {**GigabitEthernet** | **TenGigE**} *instance*
20. **bundle id** *bundle-id* [**mode** {**active** | **on** | **passive**}]
21. **no shutdown**
22. Repeat Step 19 through Step 21 to add more Ethernet interfaces to the bundle you created in Step 2.

23. **end**
    or
    commit
24. Perform Step 1 through Step 23 on the remote end of the connection.
25. **show bundle Bundle-Ether** *bundle-id* [**reasons**]
26. **show ethernet trunk bundle-Ether** *instance*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface Bundle-Ether** *bundle-id* **Example:** `RP/0/RSP0/CPU0:router#(config)# interface Bundle-Ether 3`	Creates and names a new Ethernet link bundle. This **interface Bundle-Ether** command enters you into the interface configuration submode, where you can enter interface-specific configuration commands. Use the **exit** command to exit from the interface configuration submode back to the normal global configuration mode.
Step 3	**ipv4 address** *ipv4-address mask* **Example:** `RP/0/RSP0/CPU0:router(config-if)# ipv4 address 10.1.2.3 255.0.0.0`	Assigns an IP address and subnet mask to the virtual interface using the **ipv4 address** configuration subcommand.
Step 4	**bundle minimum-active bandwidth** *kbps* **Example:** `RP/0/RSP0/CPU0:router(config-if)# bundle minimum-active bandwidth 580000`	(Optional) Sets the minimum amount of bandwidth required before a user can bring up a bundle.
Step 5	**bundle minimum-active links** *links* **Example:** `RP/0/RSP0/CPU0:router(config-if)# bundle minimum-active links 2`	(Optional) Sets the number of active links required before you can bring up a specific bundle.

	Command or Action	Purpose
Step 6	**bundle maximum-active links** *links* **Example:** `RP/0/RSP0/CPU0:router(config-if)# bundle maximum-active links 1`	(Optional) Designates one active link and one link in standby mode that can take over immediately for a bundle if the active link fails (1:1 protection). **Note** The default number of active links allowed in a single bundle is 8. **Note** If the **bundle maximum-active** command is issued, then only the highest-priority link within the bundle is active. The priority is based on the value from the **bundle port-priority** command, where a lower value is a higher priority. Therefore, we recommend that you configure a higher priority on the link that you want to be the active link.
Step 7	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-if)# exit`	Exits the interface configuration submode.
Step 8	**interface Bundle-Ether** *bundle-id.vlan-id* **Example:** `RP/0/RSP0/CPU0:router#(config)# interface Bundle-Ether 3.1`	Creates a new VLAN, and assigns the VLAN to the Ethernet bundle you created in Step 2. Replace the *bundle-id* argument with the *bundle-id* you created in Step 2. Replace the *vlan-id* with a subinterface identifier. Range is from 1 to 4094 inclusive (0 and 4095 are reserved). **Note** When you include the *.vlan-id* argument with the **interface Bundle-Ether** *bundle-id* command, you enter subinterface configuration mode.
Step 9	**encapsulation dot1q** *vlan-id* **Example:** `RP/0/RSP0/CPU0:router#(config-subif)# encapsulation dot1q 10`	Assigns a VLAN to the subinterface. Replace the *vlan-id* argument with a subinterface identifier. Range is from 1 to 4094 inclusive (0 and 4095 are reserved).
Step 10	**ipv4 address** *ipv4-address mask* **Example:** `RP/0/RSP0/CPU0:router#(config-subif)# ipv4 address 10.1.2.3/24`	Assigns an IP address and subnet mask to the subinterface.
Step 11	**no shutdown** **Example:** `RP/0/RSP0/CPU0:router#(config-subif)# no shutdown`	(Optional) If a link is in the down state, bring it up. The **no shutdown** command returns the link to an up or down state depending on the configuration and state of the link.

	Command or Action	Purpose
Step 12	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-subif)# exit`	Exits subinterface configuration mode for the VLAN subinterface.
Step 13	Repeat Step 7 through Step 12 to add more VLANs to the bundle you created in Step 2.	(Optional) Adds more subinterfaces to the bundle.
Step 14	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-subif)# end` or `RP/0/RSP0/CPU0:router(config-subif)# commit`	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. • Use the commit command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 15	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-subif)# exit`	Exits interface configuration mode.
Step 16	**exit** **Example:** `RP/0/RSP0/CPU0:router(config)# exit`	Exits global configuration mode.
Step 17	**show ethernet trunk bundle-ether** *instance* **Example:** `RP/0/RP0/CPU0:router# show ethernet trunk bundle-ether 5`	(Optional) Displays the interface configuration. The Ethernet bundle instance range is from 1 through 65535.
Step 18	**configure** **Example:** `RP/0/RSP0/CPU0:router # configure`	Enters global configuration mode.

	Command or Action	Purpose
Step 19	**interface** {**GigabitEthernet** | **TenGigE**} *instance* **Example:** `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 1/0/0/0`	Enters the interface configuration mode for the Ethernet interface you want to add to the Bundle. Enter the **GigabitEthernet** or **TenGigE** keyword to specify the interface type. Replace the *instance* argument with the node-id in the *rack/slot/module* format. **Note** A VLAN bundle is not active until you add an Ethernet interface on both ends of the link bundle.
Step 20	**bundle id** *bundle-id* [**mode** {**active** | **on** | **passive**}] **Example:** `RP/0/RSP0/CPU0:router(config-if)# bundle-id 3`	Adds an Ethernet interface to the bundle you configured in Step 2 through Step 13. To enable active or passive LACP on the bundle, include the optional **mode active** or **mode passive** keywords in the command string. To add the interface to the bundle without LACP support, include the optional **mode on** keywords with the command string. **Note** If you do not specify the **mode** keyword, the default mode is **on** (LACP is not run over the port).
Step 21	`no shutdown` **Example:** `RP/0/RSP0/CPU0:router(config-if)# no shutdown`	(Optional) If a link is in the down state, bring it up. The **no shutdown** command returns the link to an up or down state depending on the configuration and state of the link.
Step 22	Repeat Step 19 through Step 21 to add more Ethernet interfaces to the VLAN bundle.	—

	Command or Action	Purpose
Step 23	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-subif)# end` or `RP/0/RSP0/CPU0:router(config-subif)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 24	Perform Step 1 through Step 23 on the remote end of the VLAN bundle connection.	Brings up the other end of the link bundle.
Step 25	`show bundle Bundle-Ether` *bundle-id* [**reasons**] **Example:** `RP/0/RSP0/CPU0:router# show bundle Bundle-Ether 3 reasons`	(Optional) Shows information about the specified Ethernet link bundle. The **show bundle Bundle-Ether** command displays information about the specified bundle. If your bundle has been configured properly and is carrying traffic, the State field in the **show bundle Bundle-Ether** command output will show the number "4," which means the specified VLAN bundle port is "distributing."
Step 26	**show ethernet trunk bundle-ether** *instance* **Example:** `RP/0/RP0/CPU0:router# show ethernet trunk bundle-ether 5`	(Optional) Displays the interface configuration. The Ethernet bundle instance range is from 1 through 65535.

Configuration Examples for Link Bundles

This section provides these configuration examples:

- EtherChannel Bundle running LACP: Example
- Creating VLANs on a Ethernet Bundle: Example
- ASR 9000 Link Bundles connected to a Cisco 7600 EtherChannel: Example

EtherChannel Bundle running LACP: Example

This example shows how to join two ports to form an EtherChannel bundle running LACP:

```
RP/0/RSP0/CPU0:Router# config
RP/0/RSP0/CPU0:Router(config)# interface Bundle-Ether 3
RP/0/RSP0/CPU0:Router(config-if)# ipv4 address 1.2.3.4/24
RP/0/RSP0/CPU0:Router(config-if)# bundle minimum-active bandwidth 620000
RP/0/RSP0/CPU0:Router(config-if)# bundle minimum-active links 1
RP/0/RSP0/CPU0:Router(config-if)# exit
RP/0/RSP0/CPU0:Router(config)# interface TenGigE 0/3/0/0
RP/0/RSP0/CPU0:Router(config-if)# bundle id 3 mode active
RP/0/RSP0/CPU0:Router(config-if)# no shutdown
RP/0/RSP0/CPU0:Router(config)# exit
RP/0/RSP0/CPU0:Router(config)# interface TenGigE 0/3/0/1
RP/0/RSP0/CPU0:Router(config-if)# bundle id 3 mode active
RP/0/RSP0/CPU0:Router(config-if)# no shutdown
RP/0/RSP0/CPU0:Router(config-if)# exit
```

Creating VLANs on a Ethernet Bundle: Example

This example shows how to create and bring up two VLANs on an Ethernet bundle:

```
RP/0/RSP0/CPU0:Router# config
RP/0/RSP0/CPU0:Router(config)# interface Bundle-Ether 1
RP/0/RSP0/CPU0:Router(config-if)# ipv4 address 1.2.3.4/24
RP/0/RSP0/CPU0:Router(config-if)# bundle minimum-active bandwidth 620000
RP/0/RSP0/CPU0:Router(config-if)# bundle minimum-active links 1
RP/0/RSP0/CPU0:Router(config-if)# exit
RP/0/RSP0/CPU0:Router(config)# interface Bundle-Ether 1.1
RP/0/RSP0/CPU0:Router(config-subif)# encapsulation dot1q 10
RP/0/RSP0/CPU0:Router(config-subif)# ip addr 10.2.3.4/24
RP/0/RSP0/CPU0:Router(config-subif)# no shutdown
RP/0/RSP0/CPU0:Router(config-subif)# exit
RP/0/RSP0/CPU0:Router(config)# interface Bundle-Ether 1.2
RP/0/RSP0/CPU0:Router(config-subif)# encapsulation dot1q 20
RP/0/RSP0/CPU0:Router(config-subif)# ip addr 20.2.3.4/24
RP/0/RSP0/CPU0:Router(config-subif)# no shutdown
RP/0/RSP0/CPU0:Router(config-subif)# exit
RP/0/RSP0/CPU0:Router(config)#interface gig 0/1/5/7
RP/0/RSP0/CPU0:Router(config-if)# bundle-id 1 mode act
RP/0/RSP0/CPU0:Router(config-if)# commit
RP/0/RSP0/CPU0:Router(config-if)# exit
RP/0/RSP0/CPU0:Router(config)# exit
RP/0/RSP0/CPU0:Router # show ethernet trunk bundle-ether 1
```

ASR 9000 Link Bundles connected to a Cisco 7600 EtherChannel: Example

This example is an end-to-end example of a bundle between ASR 9000 Series router (ASR-9010) and a Cisco 7600 Series Router (P19_C7609-S) in the Metro Ethernet network that supports both L2 and L3 services.

On the Cisco ASR 9000 Series Routers the bundle is configured with LACP, 1:1 link protection, two L2 subinterfaces, and two layer 3 subinterfaces.

IOS XR side:

```
hostname PE44_ASR-9010

interface Bundle-Ether16
 description Connect to P19_C7609-S Port-Ch 16
 mtu 9216
 no ipv4 address
 bundle maximum-active links 1
!
interface Bundle-Ether16.160 l2transport
 description Connect to P19_C7609-S Port-Ch 16 EFP 160
 encapsulation dot1q 160
!
interface Bundle-Ether16.161 l2transport
 description Connect to P19_C7609-S Port-Ch 16 EFP 161
 encapsulation dot1q 161
!
interface Bundle-Ether16.162
 description Connect to P19_C7609-S Port-Ch 16.162
 ipv4 address 10.194.8.44 255.255.255.0
 encapsulation dot1q 162
!
interface Bundle-Ether16.163
 description Connect to P19_C7609-S Port-Ch 16.163
 ipv4 address 10.194.12.44 255.255.255.0
 encapsulation dot1q 163
!


interface GigabitEthernet0/1/0/16
 description Connected to P19_C7609-S GE 8/0/16
 bundle id 16 mode active
 bundle port-priority 1
!
interface GigabitEthernet0/1/0/17
 description Connected to P19_C7609-S GE 8/0/17
 bundle id 16 mode active
 bundle port-priority 2
!
```

IOS XR side - connections to CE devices:

```
hostname PE44_ASR-9010

interface GigabitEthernet0/1/0/3.160 l2transport
 description VLAN 160 over BE 16.160
 encapsulation dot1q 100 second-dot1q 160
 rewrite ingress tag pop 1 symmetric
!
interface GigabitEthernet0/1/0/3.161 l2transport
 description VLAN 161 over BE 16.161
 encapsulation dot1q 161
!
l2vpn
 !
 xconnect group 160
  p2p 160
   interface Bundle-Ether16.160
   interface GigabitEthernet0/1/0/3.160
   description VLAN_160_over_BE_16.160
  !
 !
 xconnect group 161
  p2p 161
   interface Bundle-Ether16.161
   interface GigabitEthernet0/1/0/3.161
   description VLAN_161_over_BE_16.161
  !
 !
```

IOS XR side - CE devices:

```
hostname PE64_C3750-ME
!
vlan 161
!
interface GigabitEthernet1/0/1
 description Connected to PE65_ME-C3400 GE 0/1
 switchport access vlan 100
 switchport mode dot1q-tunnel
!
interface GigabitEthernet1/0/2
 description Connected to PE44_ASR-9010 GE 0/1/0/3
 switchport trunk encapsulation dot1q
 switchport trunk allowed vlan 100,161
 switchport mode trunk
!
interface Vlan161
 description VLAN 161 over BE 16.161 on PE44
 ip address 161.0.0.64 255.255.255.0
!



hostname PE65_ME-C3400
!
vlan 160
!
interface GigabitEthernet0/1
 description Connected to PE64_C3750-ME GE 1/0/1
 port-type nni
```

```
 switchport trunk allowed vlan 160
 switchport mode trunk
!
interface Vlan160
 description VLAN 160 over BE 16.160 on PE44
 ip address 160.0.0.65 255.255.255.0
!
```

IOS side:

```
hostname P19_C7609-S

port-channel load-balance src-dst-port
!
interface Port-channel16
 description Connected to PE44_ASR-9010 BE 16
 mtu 9202
 no ip address
 logging event link-status
 logging event status
 speed nonegotiate
 mls qos trust dscp
 lacp fast-switchover
 lacp max-bundle 1
 service instance 160 ethernet
  description Connected to PE44_ASR-9010 BE 16.160
  encapsulation dot1q 160
 !
 service instance 161 ethernet
  description Connected to PE44_ASR-9010 BE 16.161
  encapsulation dot1q 161
 !
!
interface Port-channel16.162
 description Connected to PE44_ASR-9010 BE 16.162
 encapsulation dot1Q 162
 ip address 10.194.8.19 255.255.255.0
!
interface Port-channel16.163
 description Connected to PE44_ASR-9010 BE 16.163
 encapsulation dot1Q 163
 ip address 10.194.12.19 255.255.255.0
!

interface GigabitEthernet8/0/16
 no shut
 description Connected to PE44_ASR-9010 GE 0/1/0/16
 mtu 9202
 no ip address
 logging event link-status
 logging event status
 speed nonegotiate
 no mls qos trust dscp
 lacp port-priority 1
 channel-protocol lacp
 channel-group 16 mode active
!
interface GigabitEthernet8/0/17
 no shut
 description Connected to PE44_ASR-9010 GE 0/1/0/17
 mtu 9202
 no ip address
```

```
 logging event link-status
 logging event status
 speed nonegotiate
 no mls qos trust dscp
 lacp port-priority 2
 channel-protocol lacp
 channel-group 16 mode active
!
```

IOS side - connections to CE devices:

```
hostname P19_C7609-S

interface GigabitEthernet8/0/7
 description Connected to PE62_C3750-ME GE 1/0/2
 mtu 9000
 no ip address
 speed nonegotiate
 mls qos trust dscp
 service instance 160 ethernet
  description VLAN 160 over Port-Ch 16
  encapsulation dot1q 100 second-dot1q 160
  rewrite ingress tag pop 1 symmetric
 !
 service instance 161 ethernet
  description VLAN 161 over Port-Ch 16
  encapsulation dot1q 161
 !
!
connect eline-161 Port-channel16 161 GigabitEthernet8/0/7 161
 !
!
connect eline-160 Port-channel16 160 GigabitEthernet8/0/7 160
 !
!
```

IOS side - CE devices:

```
hostname PE62_C3750-ME
!
vlan 161
!
interface GigabitEthernet1/0/1
 description Connected to PE63_ME-C3400 GE 0/1
 switchport access vlan 100
 switchport mode dot1q-tunnel
!
interface GigabitEthernet1/0/2
 description Connected to P19_C7609-S GE 8/0/7
 switchport trunk encapsulation dot1q
 switchport trunk allowed vlan 100,161
 switchport mode trunk
!
interface Vlan161
 description VLAN 161 over Port-Chan 16 on P19
 ip address 161.0.0.62 255.255.255.0
!
```

```
hostname PE63_ME-C3400
!
vlan 160
!
interface GigabitEthernet0/1
 description Connected to PE62_C3750-ME GE 1/0/1
 port-type nni
 switchport trunk allowed vlan 160
 switchport mode trunk
!
interface Vlan160
 description VLAN 160 over Port-Chan 16 on P19
 ip address 160.0.0.63 255.255.255.0
!
```

Additional References

These sections provide references related to link bundle configuration.

Related Documents

Related Topic	Document Title
Cisco ASR 9000 Series Routers master command reference	*Cisco ASR 9000 Series Routers Master Commands List*
Cisco ASR 9000 Series Routers interface configuration commands	*Cisco ASR 9000 Series Routers Interface and Hardware Component Command Reference*
Initial system bootup and configuration information for a Cisco ASR 9000 Series Routers using the Cisco IOS XR Software.	*Cisco ASR 9000 Series Routers Getting Started Guide*
Information about user groups and task IDs	*Cisco ASR 9000 Series Routers Interface and Hardware Component Command Reference*
Information about configuring interfaces and other components on the Cisco ASR 9000 Series Routers from a remote Craft Works Interface (CWI) client management application	*Cisco ASR 9000 Series Routers Craft Works Interface Configuration Guide*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
There are no applicable MIBs for this module.	To locate and download MIBs for selected platforms using Cisco IOS XR Software, use the Cisco MIB Locator found at this URL: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport

Implementing Point to Point Layer 2 Services

This module provides conceptual and configuration information for point-to-point Layer 2 (L2) connectivity on Cisco ASR 9000 Series Aggregation Services Routers.

These point-to-point services are supported:

- local switching—A point-to-point circuit internal to a single Cisco ASR 9000 Series Router, also known as local connect.
- pseudowires—A virtual point-to-point circuit from a Cisco ASR 9000 Series Router. Pseudowires are implemented over MPLS.

Note For more information about MPLS Layer 2 VPN on the Cisco ASR 9000 Series Router and for descriptions of the commands listed in this module, see the "Related Documents" section. To locate documentation for other commands that might appear while executing a configuration task, search online in the Cisco IOS XR software master command index.

Feature History for Implementing MPLS Layer 2 VPN on Cisco ASR 9000 Series Routers

Release	Modification
Release 3.7.2	This feature was introduced on Cisco ASR 9000 Series Routers.
Release 3.9.0	Scale enhancements were introduced. See Table 4 on page 391 for more information on scale enhancements.
Release 4.0.0	Support was added for Any Transport over MPLS (AToM) features.
Release 4.0.1	Support was added for these features: • Pseudowire Load Balancing • Any Transport over MPLS (AToM) features: – HDLC over MPLS (HDLCoMPLS) – PPP over MPLS (PPPoMPLS)
Release 4.1.0	Support was added for the Flexible Router ID feature.
Release 4.2.0	Support was added for these features: • MPLS Transport Profile • Circuit EMulation (CEM) over Packet

Contents

Prerequisites for Implementing Point to Point Layer 2 Services

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.

Information About Implementing Point to Point Layer 2 Services

To implement Point to Point Layer 2 Services, you should understand These concepts:

Layer 2 Virtual Private Network Overview

Layer 2 Virtual Private Network (L2VPN) emulates the behavior of a LAN across an L2 switched, IP or MPLS-enabled IP network, allowing Ethernet devices to communicate with each other as they would when connected to a common LAN segment. Point-to-point L2 connections are vital when creating L2VPNs.

As Internet service providers (ISPs) look to replace their Frame Relay or Asynchronous Transfer Mode (ATM) infrastructures with an IP infrastructure, there is a need to provide standard methods of using an L2 switched, IP or MPLS-enabled IP infrastructure. These methods provide a serviceable L2 interface to customers; specifically, to provide virtual circuits between pairs of customer sites.

Building a L2VPN system requires coordination between the ISP and the customer. The ISP provides L2 connectivity; the customer builds a network using data link resources obtained from the ISP. In an L2VPN service, the ISP does not require information about a the customer's network topology, policies, routing information, point-to-point links, or network point-to-point links from other ISPs.

The ISP requires provider edge (PE) routers with these capabilities:

- Encapsulation of L2 protocol data units (PDU) into Layer 3 (L3) packets.
- Interconnection of any-to-any L2 transports.
- Emulation of L2 quality-of-service (QoS) over a packet switch network.
- Ease of configuration of the L2 service.
- Support for different types of tunneling mechanisms (MPLS, IPSec, GRE, and others).
- L2VPN process databases include all information related to circuits and their connections.

Layer 2 Local Switching Overview

Local switching allows you to switch L2 data between two interfaces of the same type, (for example, Ethernet to Ethernet) and on the same router. The interfaces can be on the same line card, or on two different line cards. During these types of switching, Layer 2 address is used instead of the Layer 3 address. A local switching connection switches L2 traffic from one attachment circuit (AC) to the other. The two ports configured in a local switching connection are ACs with respect to that local connection. A local switching connection works like a bridge domain that has only two bridge ports; traffic enters one port of the local connection and leaves the other. However, because there is no bridging involved in a local connection, there is neither MAC learning nor flooding. Also, the ACs in a local connection are not in the UP state if the interface state is DOWN. (This behavior is also different when compared to that of a bridge domain.)

Local switching ACs utilize a full variety of L2 interfaces, including L2 trunk (main) interfaces, bundle interfaces, and EFPs.

Additionally, same-port local switching allows you to switch Layer 2 data between two circuits on the same interface.

ATMoMPLS with L2VPN Overview

ATMoMPLS is a type of Layer 2 point-to-point connection over an MPLS core.

To implement the ATMoMPLS feature, the Cisco ASR 9000 Series Router plays the role of provider edge (PE) router at the edge of a provider network in which customer edge (CE) devices are connected to the Cisco ASR 9000 Series Routers.

Virtual Circuit Connection Verification on L2VPN

Virtual Circuit Connection Verification (VCCV) is an L2VPN Operations, Administration, and Maintenance (OAM) feature that allows network operators to run IP-based provider edge-to-provider edge (PE-to-PE) keepalive protocol across a specified pseudowire to ensure that the pseudowire data

path forwarding does not contain any faults. The disposition PE receives VCCV packets on a control channel, which is associated with the specified pseudowire. The control channel type and connectivity verification type, which are used for VCCV, are negotiated when the pseudowire is established between the PEs for each direction.

Two types of packets can arrive at the disposition egress:

- Type 1—Specifies normal Ethernet-over-MPLS (EoMPLS) data packets.
- Type 2—Specifies VCCV packets.

Cisco ASR 9000 Series Routers supports Label Switched Path (LSP) VCCV Type 1, which uses an inband control word if enabled during signaling. The VCCV echo reply is sent as IPv4 that is the reply mode in IPv4. The reply is forwarded as IP, MPLS, or a combination of both.

VCCV pings counters that are counted in MPLS forwarding on the egress side. However, on the ingress side, they are sourced by the route processor and do not count as MPLS forwarding counters.

Ethernet over MPLS

Ethernet-over-MPLS (EoMPLS) provides a tunneling mechanism for Ethernet traffic through an MPLS-enabled L3 core and encapsulates Ethernet protocol data units (PDUs) inside MPLS packets (using label stacking) to forward them across the MPLS network.

EoMPLS features are described in These subsections:

- Ethernet Port Mode, page LSC-108
- VLAN Mode, page LSC-109
- Inter-AS Mode, page LSC-110
- QinQ Mode, page LSC-110
- QinAny Mode, page LSC-111

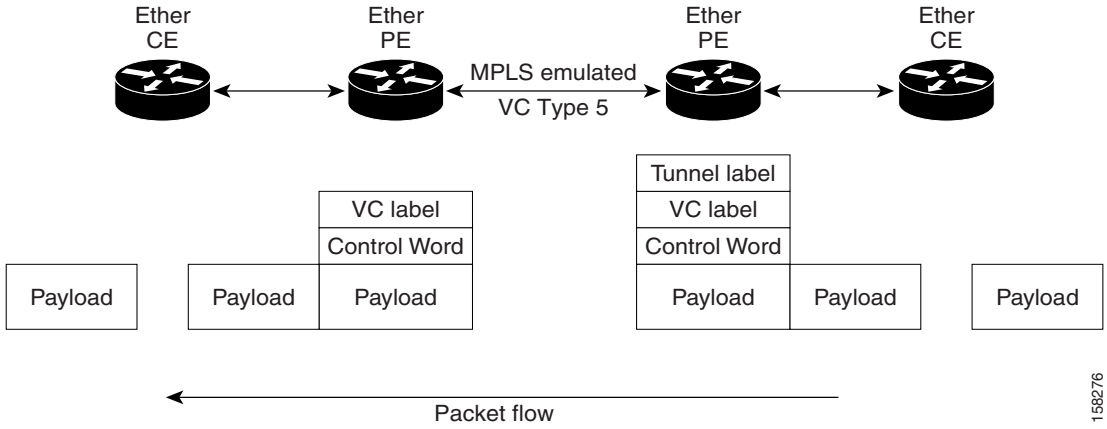
Ethernet Port Mode

In Ethernet port mode, both ends of a pseudowire are connected to Ethernet ports. In this mode, the port is tunneled over the pseudowire or, using local switching (also known as an *attachment circuit-to-attachment circuit cross-connect*) switches packets or frames from one attachment circuit (AC) to another AC attached to the same PE node.

Figure 1 provides an example of Ethernet port mode.

Figure 1 Ethernet Port Mode Packet Flow

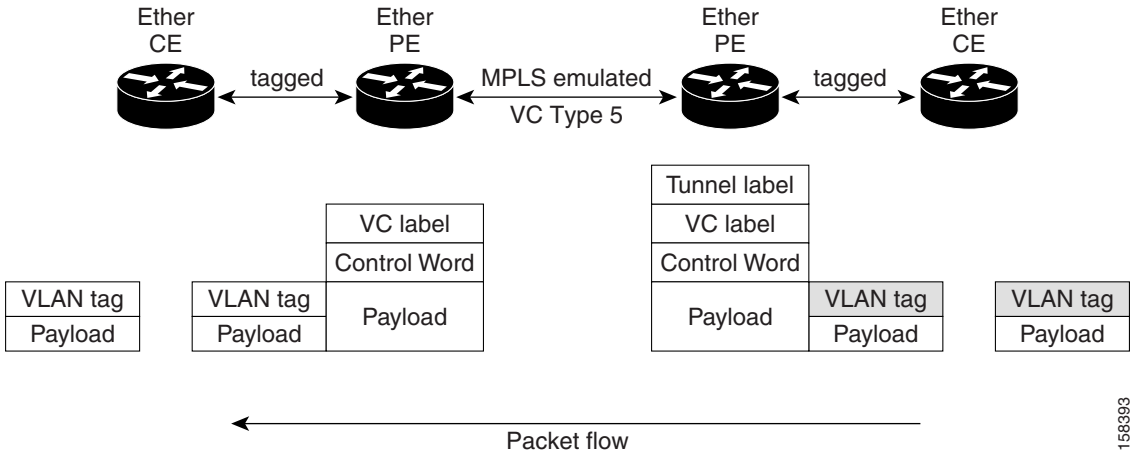
VLAN Mode



In VLAN mode, each VLAN on a customer-end to provider-end link can be configured as a separate L2VPN connection using virtual connection (VC) type 4 or VC type 5. VC type 5 is the default mode.

As illustrated in Figure 2, the Ethernet PE associates an internal VLAN-tag to the Ethernet port for switching the traffic internally from the ingress port to the pseudowire; however, before moving traffic into the pseudowire, it removes the internal VLAN tag.

Figure 2 VLAN Mode Packet Flow



At the egress VLAN PE, the PE associates a VLAN tag to the frames coming off of the pseudowire and after switching the traffic internally, it sends out the traffic on an Ethernet trunk port.

Note Because the port is in trunk mode, the VLAN PE doesn't remove the VLAN tag and forwards the frames through the port with the added tag.

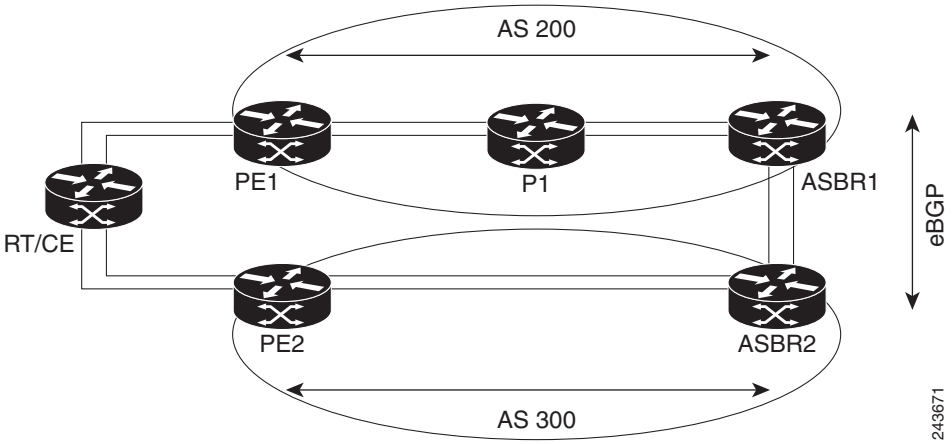
Inter-AS Mode

Inter-AS is a peer-to-peer type model that allows extension of VPNs through multiple provider or multi-domain networks. This lets service providers peer up with one another to offer end-to-end VPN connectivity over extended geographical locations.

EoMPLS support can assume a single AS topology where the pseudowire connecting the PE routers at the two ends of the point-to-point EoMPLS cross-connects resides in the same autonomous system; or multiple AS topologies in which PE routers can reside on two different ASs using iBGP and eBGP peering.

Figure 3 illustrates MPLS over Inter-AS with a basic double AS topology with iBGP/LDP in each AS.

Figure 3 EoMPLS over Inter-AS: Basic Double AS Topology



QinQ Mode

QinQ is an extension of 802.1Q for specifying multiple 802.1Q tags (IEEE 802.1QinQ VLAN Tag stacking). Layer 3 VPN service termination and L2VPN service transport are enabled over QinQ sub-interfaces.

The Cisco ASR 9000 Series Routers implement the Layer 2 tunneling or Layer 3 forwarding depending on the subinterface configuration at provider edge routers. This function only supports up to two QinQ tags on the SPA and fixed PLIM:

- Layer 2 QinQ VLANs in L2VPN attachment circuit: QinQ L2VPN attachment circuits are configured under the Layer 2 transport subinterfaces for point-to-point EoMPLS based cross-connects using both virtual circuit type 4 and type 5 pseudowires and point-to-point local-switching-based cross-connects including full interworking support of QinQ with 802.1q VLANs and port mode.
- Layer 3 QinQ VLANs: Used as a Layer 3 termination point, both VLANs are removed at the ingress provider edge and added back at the remote provider edge as the frame is forwarded.

Layer 3 services over QinQ include:

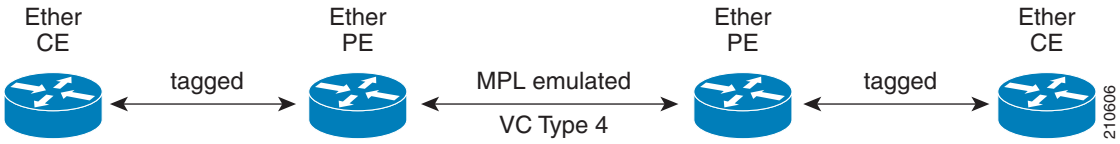
- IPv4 unicast and multicast
- IPv6 unicast and multicast
- MPLS

- Connectionless Network Service (CLNS) for use by Intermediate System-to-Intermediate System (IS-IS) Protocol

In QinQ mode, each CE VLAN is carried into an SP VLAN. QinQ mode should use VC type 5, but VC type 4 is also supported. On each Ethernet PE, you must configure both the inner (CE VLAN) and outer (SP VLAN).

Figure 4 illustrates QinQ using VC type 4.

Figure 4 EoMPLS over QinQ Mode



QinAny Mode

In the QinAny mode, the service provider VLAN tag is configured on both the ingress and the egress nodes of the provider edge VLAN. QinAny mode is similar to QinQ mode using a Type 5 VC, except that the customer edge VLAN tag is carried in the packet over the pseudowire, as the customer edge VLAN tag is unknown.

Quality of Service

Using L2VPN technology, you can assign a quality of service (QoS) level to both Port and VLAN modes of operation.

L2VPN technology requires that QoS functionality on PE routers be strictly L2-payload-based on the edge-facing interfaces (also know as *attachment circuits*). Figure 5 illustrates L2 and L3 QoS service policies in a typical L2VPN network.

Figure 5 L2VPN QoS Feature Application

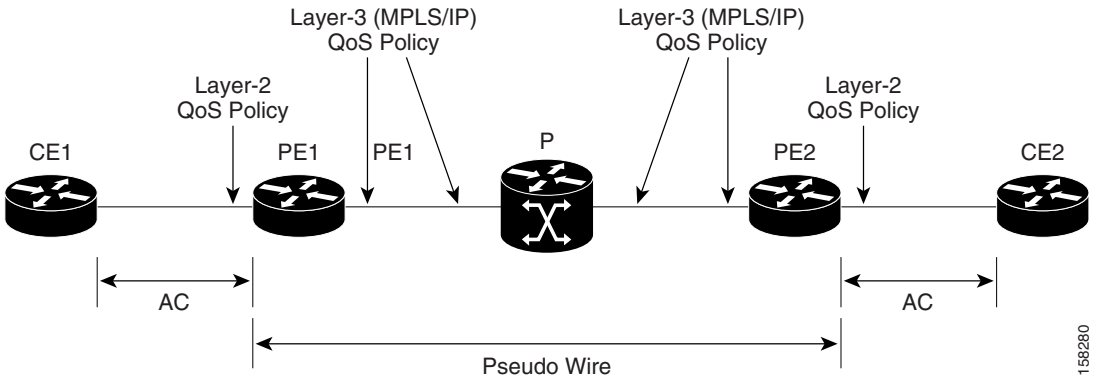
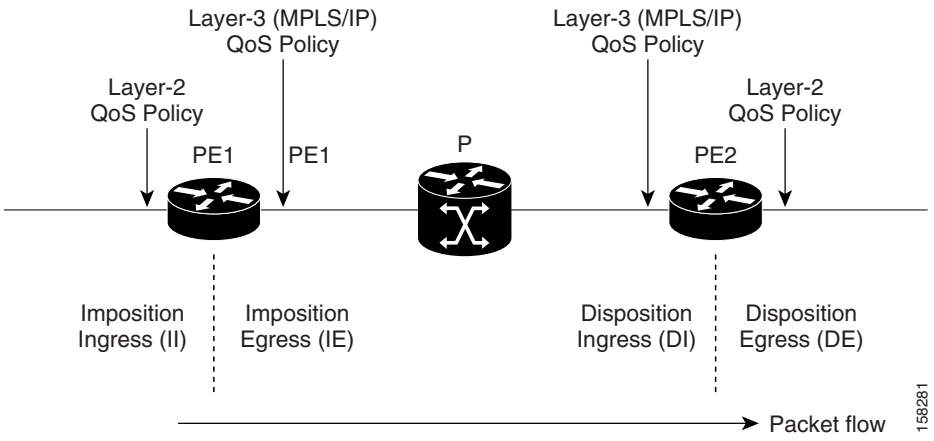


Figure 6 shows four packet processing paths within a provider edge device where a QoS service policy can be attached. In an L2VPN network, packets are received and transmitted on the edge-facing interfaces as L2 packets and transported on the core-facing interfaces as MPLS (EoMPLS) packets.

Figure 6 L2VPN QoS Reference Model



High Availability

L2VPN uses control planes in both route processors and line cards, as well as forwarding plane elements in the line cards.

The availability of L2VPN meets these requirements:

- A control plane failure in either the route processor or the line card will not affect the circuit forwarding path.
- The router processor control plane supports failover without affecting the line card control and forwarding planes.
- L2VPN integrates with existing Label Distribution Protocol (LDP) graceful restart mechanism.

Preferred Tunnel Path

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

Note

- Currently, preferred tunnel path configuration applies only to MPLS encapsulation.

Multisegment Pseudowire

Pseudowires transport Layer 2 protocol data units (PDUs) across a public switched network (PSN). A multisegment pseudowire is a static or dynamically configured set of two or more contiguous pseudowire segments. These segments act as a single pseudowire, allowing you to:

- Manage the end-to-end service by separating administrative or provisioning domains.
- Keep IP addresses of provider edge (PE) nodes private across interautonomous system (inter-AS) boundaries. Use IP address of autonomous system boundary routers (ASBRs) and treat them as pseudowire aggregation routers. The ASBRs join the pseudowires of the two domains.

A multisegment pseudowire can span either an inter-AS boundary or two multiprotocol label switching (MPLS) networks.

A pseudowire is a tunnel between two PE nodes. There are two types of PE nodes:

- A Switching PE (S-PE) node
  - Terminates PSN tunnels of the preceding and succeeding pseudowire segments in a multisegment pseudowire.
  - Switches control and data planes of the preceding and succeeding pseudowire segments of the multisegment pseudowire.
- A Terminating PE (T-PE) node
  - Located at both the first and last segments of a multisegment pseudowire.
  - Where customer-facing attachment circuits (ACs) are bound to a pseudowire forwarder.

Pseudowire Redundancy

Pseudowire redundancy allows you to configure your network to detect a failure in the network and reroute the Layer 2 service to another endpoint that can continue to provide service. This feature provides the ability to recover from a failure of either the remote provider edge (PE) router or the link between the PE and customer edge (CE) routers.

L2VPNs can provide pseudowire resiliency through their routing protocols. When connectivity between end-to-end PE routers fails, an alternative path to the directed LDP session and the user data takes over. However, there are some parts of the network in which this rerouting mechanism does not protect against interruptions in service.

Pseudowire redundancy enables you to set up backup pseudowires. You can configure the network with redundant pseudowires and redundant network elements.

Prior to the failure of the primary pseudowire, the ability to switch traffic to the backup pseudowire is used to handle a planned pseudowire outage, such as router maintenance.

Note Pseudowire redundancy is provided only for point-to-point Virtual Private Wire Service (VPWS) pseudowires.

Pseudowire Load Balancing

To maximize networks while maintaining redundancy typically requires traffic load balancing over multiple links. To achieve better and more uniformed distribution, load balancing on the traffic flows that are part of the provisioned pipes is desirable. Load balancing can be flow based according to the IP addresses, Mac addresses, or a combination of those. Load balancing can be flow based according to source or destination IP addresses, or source or destination MAC addresses. Traffic falls back to default flow based MAC addresses if the IP header cannot proceed or IPv6 is be flow based.

This feature applies to pseudowires under L2VPN; this includes both VPWS and VPLS.

Note Enabling virtual circuit (VC) label based load balancing for a pseudowire class overrides global flow based load balancing under L2VPN.

Ethernet Wire Service

An Ethernet Wire Service is a service that emulates a point-to-point Ethernet segment. This is similar to Ethernet private line (EPL), a Layer 1 point-to-point service, except the provider edge operates at Layer 2 and typically runs over a Layer 2 network. The EWS encapsulates all frames that are received on a particular UNI and transports these frames to a single-egress UNI without reference to the contents contained within the frame. The operation of this service means that an EWS can be used with VLAN-tagged frames. The VLAN tags are transparent to the EWS (bridge protocol data units [BPDUs])—with some exceptions. These exceptions include IEEE 802.1x, IEEE 802.2ad, and IEEE 802.3x, because these frames have local significance and it benefits both the customer and the Service Provider to terminate them locally.

The customer side has these types:

- Untagged
- Single tagged
- Double tagged
- 802.1q
- 802.1ad

E-Line Service

E-Line service provides a point-to-point EVC between two UNIs. There are two types of E-Line services:

- Ethernet Private Line (EPL)
  - No service multiplexing allowed
  - Transparent
  - No coordination between customer and SP on VLAN ID map
- Ethernet Virtual Private Line (EVPL)
  - Allows service multiplexing
  - No need for full transparency of service frames

Ethernet LAN (E-LAN) Service

E-LAN service provides multipoint connectivity (can connect two or more UNIs). All sites have Ethernet connectivity with each other (inside the cloud is a multipoint-to-multipoint EVC).

Types of E-LAN services:

Transparent LAN Service (TLS)

- Bundled service

Ethernet Virtual Connection Service (EVCS)

- Per-VLAN service-multiplexed service

The Cisco Ethernet Relay Service concept corresponds to the MEF Ethernet Virtual Private Line concept. The Cisco Ethernet Wire Service concept corresponds to the MEF Ethernet Private Line concept. The Cisco Multipoint Service concept corresponds to the MEF Transparent LAN Service concept. The Cisco Multipoint Relay Service concept corresponds to the MEF Ethernet Virtual Connection Service concept. A UNI is the demarcation between the CE and the provider edge (PE).

Ethernet service is what the Service Provider provides between UNIs.

- Ethernet Line service (E-Line) point-to-point
- Ethernet LAN service (E-LAN) multipoint
- Ethernet Tree service (E-Tree) point-to-multipoint

This is Carrier Ethernet. This can replace Frame Relay/ATM within the cloud with the benefits including faster speeds (GigE and 10GigE). VPLS (Virtual Private LAN Service) is an end-to-end architecture that allows MPLS networks to provide Multipoint Ethernet services. It is “Virtual” because multiple instances of this service share the same physical infrastructure. It is “Private” because each instance of the service is independent and isolated from one another. It is “LAN Service” because it emulates Layer 2 multipoint connectivity between subscribers.

IGMP Snooping

IGMP snooping provides a way to constrain multicast traffic at Layer 2. By snooping the IGMP membership reports sent by hosts in the bridge domain, the IGMP snooping application can set up Layer 2 multicast forwarding tables to deliver traffic only to ports with at least one interested member, significantly reducing the volume of multicast traffic.

Configured at Layer 3, IGMP provides a means for hosts in an IPv4 multicast network to indicate which multicast traffic they are interested in and for routers to control and limit the flow of multicast traffic in the network (at Layer 3).

IGMP snooping uses the information in IGMP membership report messages to build corresponding information in the forwarding tables to restrict IP multicast traffic at Layer 2. The forwarding table entries are in the form <Route, OIF List>, where:

- Route is a <*, G> route or <S, G> route.
- OIF List comprises all bridge ports that have sent IGMP membership reports for the specified route plus all Multicast Router (mrouter) ports in the bridge domain.

The IGMP snooping feature can provide these benefits to a multicast network:

- Basic IGMP snooping reduces bandwidth consumption by reducing multicast traffic that would otherwise flood an entire VPLS bridge domain.

- With optional configuration options, IGMP snooping can provide security between bridge domains by filtering the IGMP reports received from hosts on one bridge port and preventing leakage towards the hosts on other bridge ports.
- With optional configuration options, IGMP snooping can reduce the traffic impact on upstream IP multicast routers by suppressing IGMP membership reports (IGMPv2) or by acting as an IGMP proxy reporter (IGMPv3) to the upstream IP multicast router.

Refer to the *Implementing Layer 2 Multicast with IGMP Snooping* module in the *Cisco ASR 9000 Series Aggregation Services Router Multicast Configuration Guide* for information on configuring IGMP snooping.

The applicable IGMP snooping commands are described in the *Cisco ASR 9000 Series Aggregation Services Router Multicast Command Reference*.

IP Interworking

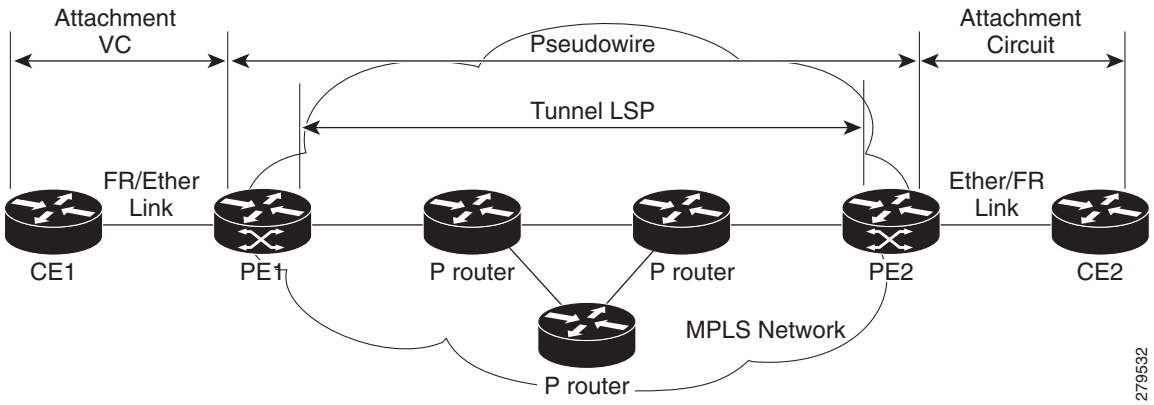
Customer deployments require a solution to support AToM with disparate transport at network ends. This solution must have the capability to translate transport on one customer edge (CE) device to another transport, for example, Frame relay to Ethernet. The Cisco ASR 9000 Series SPA Interface Processor-700 and the Cisco ASR 9000 Series Ethernet line cards enable the Cisco ASR 9000 Series Routers to support multiple legacy services.

IP Interworking is a solution for transporting Layer 2 traffic over an IP/MPLS backbone. It accommodates many types of Layer 2 frames such as Ethernet and Frame Relay using AToM tunnels. It encapsulates packets at the provider edge (PE) router, transports them over the backbone to the PE router on the other side of the cloud, removes the encapsulation, and transports them to the destination. The transport layer can be Ethernet on one end and Frame relay on the other end. IP interworking occurs between disparate endpoints of the AToM tunnels.

Note Only routed interworking is supported between Ethernet and Frame Relay based networks for MPLS and Local-connect scenarios.

Figure 7 shows the interoperability between an Ethernet attachment VC and a Frame Relay attachment VC.

Figure 7 IP Interworking over MPLS Core



An attachment circuit (AC) is a physical or logical port or circuit that connects a CE device to a PE device. A pseudowire (PW) is a bidirectional virtual connection (VC) connecting two ACs. In an MPLS network, PWs are carried inside an LSP tunnel. The core facing line card on the PE1 and PE2 could be a Cisco ASR 9000 Series SPA Interface Processor-700 or a Cisco ASR 9000 Series Ethernet line card.

In the IP Interworking mode, the Layer 2 (L2) header is removed from the packets received on an ingress PE, and only the IP payload is transmitted to the egress PE. On the egress PE, an L2 header is appended before the packet is transmitted out of the egress port.

In Figure 7, CE1 and CE2 could be a Frame Relay (FR) interface or a GigabitEthernet (GigE) interface. Assuming CE1 is a FR and CE2 is either a GigE or dot1q, or QinQ. For packets arriving from an Ethernet CE (CE2), ingress LC on the PE (PE2) facing the CE removes L2 framing and forwards the packet to egress PE (PE1) using IPoMPLS encapsulation over a pseudowire. The core facing line card on egress PE removes the MPLS labels but preserves the control word and transmits it to the egress line card facing FR CE (CE1). At the FR PE, after label disposition, the Layer 3 (L3) packets are encapsulated over FR.

Similarly, IP packets arriving from the FR CE are translated into IPoMPLS encapsulation over the pseudowire. At the Ethernet PE side, after label disposition, the PE adds L2 Ethernet packet header back to the packet before transmitting it to the CE, as the packets coming out from the core carry only the IP payload.

These modes support IP Interworking on AToM:

- Ethernet to Frame Relay

  Packets arriving from the Ethernet CE device have MAC (port-mode, untagged, single, double tag), IPv4 header and data. The Ethernet line card removes the L2 framing and then forwards the L3 packet to the egress line card. The egress line card adds the FR L2 header before transmitting it from the egress port.

- Ethernet to Ethernet

  Both the CE devices are Ethernet. Each ethernet interface can be port-mode, untagged, single, or double tag, although this is not a typical scenario for IP interworking.

Any Transport over MPLS

Any Transport over MPLS (AToM) transports Layer 2 packets over a Multiprotocol Label Switching (MPLS) backbone. This enables service providers to connect customer sites with existing Layer 2 networks by using a single, integrated, packet-based network infrastructure. Using this feature, service providers can deliver Layer 2 connections over an MPLS backbone, instead of using separate networks.

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

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

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

Control Word Processing

The control word contains forward explicit congestion notification (FECN), backward explicit congestion notification (BECN) and DE bits in case of frame relay connection.

Control word is mandatory for:

- Frame Relay
- ATM AAL5
- Frame Relay to Ethernet bridged interworking
- cHDLC/PPP IP interworking
- CEM (Circuit Emulation)

The system does not map bits from one transport end point to another across an AToM IP Interworking connection.

Whenever supported, control word is also recommended for pseudowires, as it enables proper load balancing without packet desequencing independent of L2VPN packet content. Without control word the heuristics used to perform load balancing cannot achieve optimal results in all cases.

High-level Data Link Control over MPLS

The attachment circuit (AC) is a main interface configured with HDLC encapsulation. Packets to or from the AC are transported using an AToM pseudowire (PW) of VC type 0x6 to or from the other provider edge (PE) router over the MPLS core network.

With HDLC over MPLS, the entire HDLC packet is transported. The ingress PE router removes only the HDLC flags and FCS bits.

PPP over MPLS

The attachment circuit (AC) is a main interface configured with PPP encapsulation. Packets to or from the AC are transported through an AToM PW of VC type 0x7 to or from the other provider edge (PE) routers over the MPLS core network.

With PPP over MPLS, the ingress PE router removes the flags, address, control field, and the FCS bits.

Frame Relay over MPLS

Frame Relay over MPLS (FRoMPLS) provides leased line type of connectivity between two Frame Relay islands. Frame Relay traffic is transported over the MPLS network.

Note The Data Link Connection Identifier (DLCI) DCLI-DLCI mode is supported. A control word (required for DLCI-DLCI mode) is used to carry additional control information.

When a Provider Edge (PE) router receives a Frame Relay protocol packet from a subscriber site, it removes the Frame Relay header and Frame Check Sequence (FCS) and appends the appropriate Virtual Circuit (VC) label. The removed Backward Explicit Congestion Notification (BECN), Forward Explicit Congestion Notification (FECN), Discard Eligible (DE) and Command/Response (C/R) bits are (for DLCI-DLCI mode) sent separately using a control word.

MPLS Transport Profile

MPLS transport profile (MPLS-TP) tunnels provide the transport network service layer over which IP and MPLS traffic traverse. Within the MPLS-TP environment, pseudowires (PWs) use MPLS-TP tunnels as the transport mechanism. MPLS-TP tunnels help transition from SONET/SDH TDM technologies to packet switching, to support services with high bandwidth utilization and low cost. Transport networks are connection oriented, statically provisioned, and have long-lived connections. Transport networks usually avoid control protocols that change identifiers (like labels). MPLS-TP tunnels provide this functionality through statically provisioned bidirectional label switched paths (LSPs).

For more information on configuring MPLS transport profile, refer to the *Cisco ASR 9000 Series Aggregation Services Router MPLS Configuration Guide*.

MPLS-TP supports these combinations of static and dynamic multisegment pseudowires:

- Static-static
- Static-dynamic
- Dynamic-static
- Dynamic-dynamic

MPLS-TP supports one-to-one L2VPN pseudowire redundancy for these combinations of static and dynamic pseudowires:

- Static pseudowire with a static backup pseudowire
- Static pseudowire with a dynamic backup pseudowire
- Dynamic pseudowire with a static backup pseudowire
- Dynamic pseudowire with a dynamic backup pseudowire

The existing TE preferred path feature is used to pin down a PW to an MPLS-TP transport tunnel. See Configuring Preferred Tunnel Path, page LSC-150 for more information on configuring preferred tunnel path. For a dynamic pseudowire, PW status is exchanged through LDP whereas for static PW, status is transported in PW OAM message. See Configuring PW Status OAM, page LSC-152 for more information on configuring PW status OAM. By default, alarms are not generated when the state of a PW changes due to change in the state of MPLS TP tunnel carrying that PW. See Configuring Pseudowire Event Suppression, page LSC-153 for more information on configuring PW event suppression.

Circuit Emulation Over Packet Switched Network

Circuit Emulation over Packet (CEoP) is a method of carrying TDM circuits over packet switched network. CEoP is similar to a physical connection. The goal of CEoP is to replace leased lines and legacy TDM networks (Figure 8).

CEoP operates in two major modes:

- Unstructured mode is called SAToP (Structure Agnostic TDM over Packet)

  SAToP addresses only structure-agnostic transport, i.e., unframed E1, T1, E3 and T3. It segments all TDM services as bit streams and then encapsulates them for transmission over a PW tunnel. This protocol can transparently transmit TDM traffic data and synchronous timing information. SAToP completely disregards any structure and provider edge routers (PEs) do not need to interpret the TDM data or to participate in the TDM signaling. The protocol is a simple way for transparent transmission of PDH bit-streams.

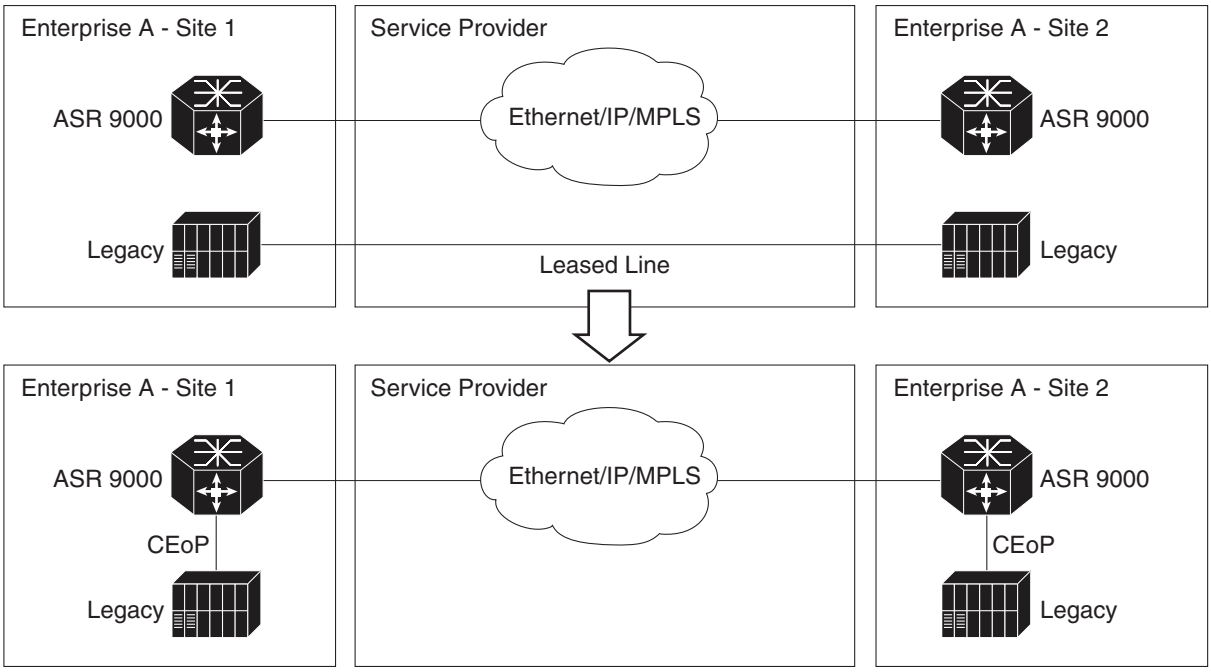
- Structured mode is named CESoPSN (Circuit Emulation Service over Packet Switched Network)

  Compared with SAToP, CESoPSN transmits emulated structured TDM signals. That is, it can identify and process the frame structure and transmit signaling in TDM frames. It may not transmit idle timeslot channels, but only extracts useful timeslots of CE devices from the E1 traffic stream and then encapsulates them into PW packets for transmission.CEoP SPAs are half-height (HH) Shared Port Adapters (SPA) and the CEoP SPA family consists of 24xT1/E1, 2xT3/E3, and 1xOC3/STM1 unstructured and structured (NxDS0) quarter rate, half height SPAs.

The CEM functionality is supported only on Engine 5 line cards having CEoP SPAs. CEM is supported on:

- 1-port Channelized OC3 STM1 ATM CEoP SPA (SPA-1CHOC3-CE-ATM)

Figure 8 Enterprise Data Convergence using Circuit Emulation over Packet



CESoPSN and SAToP can use MPLS, UDP/IP, and L2TPv3 as the underlying transport mechanism. This release supports only MPLS transport mechanism.

CEoP SPA supports these modes of operation:

- Circuit Emulation Mode (CEM)
- ATM Mode
- IMA Mode

Note Only CEM mode is supported.

Benefits of Circuit Emulation over Packet Switched Network

CEM offers thse benefits to the service provider and end-users:

- Saving cost in installing equipment.
- Saving cost in network operations; as leased lines are expensive, limiting their usage to access only mode saves significant costs.
- Ensuring low maintenance cost because only the core network needs to be maintained.
- Utilizing the core network resources more efficiently with packet switched network, while keeping investment in access network intact.
- Providing cheaper services to the end-user.

How to Implement Point to Point Layer 2 Services

This section describes the tasks required to implement L2VPN:

Configuring an Interface or Connection for L2VPN

Perform this task to configure an interface or a connection for L2VPN.

SUMMARY STEPS

1. **configure**
2. **interface** *type interface-path-id*
3. **l2transport**
4. **exit**
5. **interface** *type interface-path-id*
6. **end**
   or
   commit
7. **show interface** *type interface-id*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/0/0/0`	Enters interface configuration mode and configures an interface.
Step 3	**l2transport** **Example:** `RP/0/RSP0/CPU0:router(config-if)# l2transport`	Enables L2 transport on the selected interface.
Step 4	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-if-l2)# exit`	Exits the current configuration mode.
Step 5	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet0/0/0/0`	Enters interface configuration mode and configures an interface.

	Command or Action	Purpose
Step 6	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-if)# end` or `RP/0/RSP0/CPU0:router(config-if)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 7	**show interface** *type interface-id* **Example:** `RP/0/RSP0/CPU0:router# show interface gigabitethernet 0/0/0/0`	(Optional) Displays the configuration settings you committed for the interface.

Configuring Local Switching

Perform this task to configure local switching.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **xconnect group** *group-name*
4. **p2p** *xconnect-name*
5. **interface** *type interface-path-id*
6. **interface** *type interface-path-id*
7. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**l2vpn** **Example:** `RP/0/RSP0/CPU0:router(config)# l2vpn`	Enters L2VPN configuration mode.
Step 3	**xconnect group** *group-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group grp_1`	Enters the name of the cross-connect group.
Step 4	**p2p** *xconnect-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p vlan1`	Enters a name for the point-to-point cross-connect.
Step 5	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface TenGigE 0/7/0/6.5`	Specifies the interface type ID. The choices are: • GigabitEthernet: Gigabit Ethernet/IEEE 802.3 interfaces • TenGigE: TenGigabit Ethernet/IEEE 802.3 interfaces • CEM: Circuit Emulation interface

	Command or Action	Purpose
Step 6	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface GigabitEthernet0/4/0/30`	Specifies the interface type ID. The choices are: • GigabitEthernet: Gigabit Ethernet/IEEE 802.3 interfaces • TenGigE: TenGigabit Ethernet/IEEE 802.3 interfaces
Step 7	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Local Connection Redundancy

Perform this task to configure local connection redundancy.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **xconnect group** *group-name*
4. **p2p** *xconnect-name*
5. **backup interface** *type interface-path-id*
6. **interface** *type interface-path-id*
7. **interface** *type interface-path-id*
8. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**l2vpn** **Example:** `RP/0/RSP0/CPU0:router(config)# l2vpn`	Enters L2VPN configuration mode.
Step 3	**xconnect group** *group-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group grp_1`	Enters the name of the cross-connect group.
Step 4	**p2p** *xconnect-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p vlan1`	Enters a name for the point-to-point cross-connect.
Step 5	**backup interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# backup interface Bundle-Ether 0/7/0/6.5`	Configures local connect redundancy.
Step 6	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface Bundle-Ether 0/7/0/6.2`	Specifies the interface type ID. The choices are: • GigabitEthernet: Gigabit Ethernet/IEEE 802.3 interfaces. • TenGigE: TenGigabit Ethernet/IEEE 802.3 interfaces. • CEM: Circuit Emulation interface

	Command or Action	Purpose
Step 7	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface Bundle-Ether 0/7/0/6.1`	Specifies the interface type ID. The choices are: • GigabitEthernet: Gigabit Ethernet/IEEE 802.3 interfaces. • TenGigE: TenGigabit Ethernet/IEEE 802.3 interfaces.
Step 8	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Static Point-to-Point Cross-Connects

Perform this task to configure static point-to-point cross-connects.

Please consider this information about cross-connects when you configure static point-to-point cross-connects:

- An cross-connect is uniquely identified with the pair; the cross-connect name must be unique within a group.
- A segment (an attachment circuit or pseudowire) is unique and can belong only to a single cross-connect.
- A static VC local label is globally unique and can be used in one pseudowire only.
- No more than 16,000 cross-connects can be configured per router.

Note Static pseudowire connections do not use LDP for signaling.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **xconnect group** *group-name*
4. **p2p** *xconnect-name*
5. **interface** *type interface-path-id*
6. **neighbor** *A.B.C.D* **pw-id** *pseudowire-id*
7. **mpls static label local** {*value*} **remote** {*value*}
8. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**l2vpn** **Example:** `RP/0/RSP0/CPU0:router(config)# l2vpn`	Enters L2VPN configuration mode.
Step 3	**xconnect group** *group-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group grp_1`	Enters the name of the cross-connect group.

	Command or Action	Purpose
Step 4	**p2p** *xconnect-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p vlan1`	Enters a name for the point-to-point cross-connect.
Step 5	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface gigabitethernet 0/1/0/9`	Specifies the interface type and instance.
Step 6	**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. Optionally, you can disable the control word or set the transport-type to Ethernet or VLAN.
Step 7	**mpls static label local** {*value*} **remote** {*value*} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# mpls static label local 699 remote 890`	Configures local and remote label ID values.
Step 8	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Dynamic Point-to-Point Cross-Connects

Perform this task to configure dynamic point-to-point cross-connects.

Note For dynamic cross-connects, LDP must be up and running.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **xconnect group** *group-name*
4. **p2p** *xconnect-name*
5. **interface** *type interface-path-id*
6. **neighbor** *A.B.C.D* **pw-id** *pseudowire-id*
7. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters the configuration mode.
Step 2	**l2vpn** **Example:** `RP/0/RSP0/CPU0:router(config)# l2vpn`	Enters L2VPN configuration mode.
Step 3	**xconnect group** *group-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group grp_1`	Enters the name of the cross-connect group.
Step 4	**p2p** *xconnect-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p vlan1`	Enters a name for the point-to-point cross-connect.

	Command or Action	Purpose
Step 5	**interface** *type interface-id* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface GigabitEthernet0/0/0/0.1`	Specifies the interface type ID. The choices are: • GigabitEthernet: GigabitEthernet/IEEE 802.3 interfaces. • TenGigE: TenGigabitEthernet/IEEE 802.3 interfaces. • CEM: Circuit Emulation interface
Step 6	**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. Optionally, you can disable the control word or set the transport-type to Ethernet or VLAN.
Step 7	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Inter-AS

The Inter-AS configuration procedure is identical to the L2VPN cross-connect configuration tasks (see "Configuring Static Point-to-Point Cross-Connects" section on page MPC-130 and "Configuring Dynamic Point-to-Point Cross-Connects" section on page MPC-132) except that the remote PE IP address used by the cross-connect configuration is now reachable through iBGP peering.

Note You must be knowledgeable about IBGP, EBGP, and ASBR terminology and configurations to complete this configuration.

Configuring L2VPN Quality of Service

This section describes how to configure L2VPN quality of service (QoS) in port mode and VLAN mode.

Restrictions

The **l2transport** command cannot be used with any IP address, L3, or CDP configuration.

Configuring an L2VPN Quality of Service Policy in Port Mode

This procedure describes how to configure an L2VPN QoS policy in port mode.

Note In port mode, the interface name format does not include a subinterface number; for example, GigabitEthernet0/1/0/1.

SUMMARY STEPS

1. **configure**
2. **interface** *type interface-path-id*
3. **l2transport**
4. **service-policy** *[***input** | **output***] [policy-map-name]*
5. **end**
   or
   commit
6. **show qos interface** *type interface-path-id* **service-policy** [**input** | **output**] [*policy-map-name*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters the configuration mode.
Step 2	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet0/0/0/0`	Specifies the interface attachment circuit.
Step 3	**l2transport** **Example:** `RP/0/RSP0/CPU0:router(config-if)# l2transport`	Configures an interface or connection for L2 switching.

	Command or Action	Purpose
Step 4	**service-policy** [**input** | **output**] [*policy-map-name*] **Example:** `RP/0/RSP0/CPU0:router(config-if)# service-policy input servpol1`	Attaches a QoS policy to an input or output interface to be used as the service policy for that interface.
Step 5	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-if)# end` or `RP/0/RSP0/CPU0:router(config-if)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 6	**show qos interface** *type interface-id* **service-policy** [**input** | **output**] [*policy-map-name*] **Example:** `RP/0/RSP0/CPU0:router# show qos interface gigabitethernet 0/0/0/0 input serpol1`	(Optional) Displays the QoS service policy you defined.

Configuring an L2VPN Quality of Service Policy in VLAN Mode

This procedure describes how to configure a L2VPN QoS policy in VLAN mode.

Note In VLAN mode, the interface name must include a subinterface. For example: `GigabitEthernet 0`/1/0/1.`1`
The l2transport command must follow the interface type on the same CLI line. For example: interface `GigabitEthernet 0`/0/0/0.1 l2transport

SUMMARY STEPS

1. **configure**
2. **interface** *type interface-path-id.subinterface* **l2transport**
3. **service-policy** [**input** | **output**] [*policy-map-name*]
4. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters the configuration mode.
Step 2	**interface** *type interface-path-id.subinterface* **l2transport** **Example:** `RP/0/RP0/CPU0:router(config)# interface GigabitEthernet0/0/0/0.1 l2transport`	Configures an interface or connection for L2 switching. **Note** In VLAN Mode, you must enter the **l2transport** keyword on the same line as the interface.

	Command or Action	Purpose
Step 3	**service-policy** *[***input** | **output***]* *[policy-map-name]* **Example:** `RP/0/RP0/CPU0:router(config-if)# service-policy input servpol1`	Attaches a QoS policy to an input or output interface to be used as the service policy for that interface.
Step 4	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-if)# end` or `RP/0/RP0/CPU0:router(config-if)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Multisegment Pseudowire

This section describes these tasks:

Provisioning a Multisegment Pseudowire Configuration

Configure a multisegment pseudowire as a point-to-point (p2p) cross-connect. For more information on P2P cross-connects, see the "Configuring Static Point-to-Point Cross-Connects" section on page MPC-130.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **xconnect group** *group-name*
4. **p2p** *xconnect-name*
5. **neighbor** *A.B.C.D* **pw-id** *value*
6. **pw-class** *class-name*
7. **exit**
8. **neighbor** *A.B.C.D* **pw-id** *value*
9. **pw-class** *class-name*
10. **commit**

DETAILED STEPS

	Command	Purpose
Step 1	`configure` **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	`l2vpn` **Example:** `RP/0/RSP0/CPU0:router(config)# l2vpn`	Enters Layer 2 VPN configuration mode.

	Command	Purpose
Step 3	**xconnect group** *group-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group MS-PW1`	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 ms-pw1`	Enters P2P configuration submode.
Step 5	**neighbor** *A.B.C.D* **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 6	**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.
Step 7	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# exit`	Exits pseudowire class submode and returns the router to the parent configuration mode.
Step 8	**neighbor** *A.B.C.D* **pw-id** *value* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# neighbor 10.165.202.158 pw-id 300`	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 9	**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.
Step 10	**commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# commit`	Saves configuration changes to the running configuration file and remains in the configuration session.

Provisioning a Global Multisegment Pseudowire Description

S-PE nodes must have a description in the Pseudowire Switching Point Type-Length-Value (TLV). The TLV records all the switching points the pseudowire traverses, creating a helpful history for troubleshooting.

Each multisegment pseudowire can have its own description. For instructions, see the "Provisioning a Cross-Connect Description" section on page MPC-141. If it does not have one, this global description is used.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **description** *value*
4. **commit**

DETAILED STEPS

	Command	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**l2vpn** **Example:** `RP/0/RSP0/CPU0:router(config)# l2vpn`	Enters Layer 2 VPN configuration mode.
Step 3	**description** *value* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# description S-PE1`	Populates the Pseudowire Switching Point TLV. This TLV records all the switching points the pseudowire traverses. Each multisegment pseudowire can have its own description. If it does not have one, this global description is used.
Step 4	**commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# commit`	Saves configuration changes to the running configuration file and remains in the configuration session.

Provisioning a Cross-Connect Description

S-PE nodes must have a description in the Pseudowire Switching Point TLV. The TLV records all the switching points the pseudowire traverses, creating a history that is helpful for troubleshooting.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **xconnect group** *group-name*
4. **p2p** *xconnect-name*
5. **description** *value*
6. **commit**

DETAILED STEPS

	Command	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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 MS-PW1`	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 ms-pw1`	Enters P2P configuration submode.

	Command	Purpose
Step 5	**description** *value* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# description MS-PW from T-PE1 to T-PE2`	Populates the Pseudowire Switching Point TLV. This TLV records all the switching points the pseudowire traverses. Each multisegment pseudowire can have its own description. If it does not have one, a global description is used. For more information, see the "Provisioning a Multisegment Pseudowire Configuration" section on page MPC-138.
Step 6	**commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# commit`	Saves configuration changes to the running configuration file and remains in the configuration session.

Provisioning Switching Point TLV Security

For security purposes, the TLV can be hidden, preventing someone from viewing all the switching points the pseudowire traverses.

Virtual Circuit Connection Verification (VCCV) may not work on multisegment pseudowires with the **switching-tlv** parameter set to "hide". For more information on VCCV, see the "Virtual Circuit Connection Verification on L2VPN" section on page MPC-107.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **pw-class** *class-name*
4. **encapsulation mpls**
5. **protocol ldp**
6. **switching-tlv hide**
7. **commit**

DETAILED STEPS

	Command	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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 dynamic_mpls`	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`	Sets pseudowire encapsulation to MPLS.
Step 5	**protocol ldp** **Example:** `RP/0/RSP0/CPU0:router (config-l2vpn-pwc-encap-mpls)# protocol ldp`	Sets pseudowire signaling protocol to LDP.

	Command	Purpose
Step 6	**switching-tlv hide** **Example:** `RP/0/RSP0/CPU0:router (config-l2vpn-pwc-encap-mpls)# switching-tlv hide`	Sets pseudowire TLV to hide.
Step 7	**commit** **Example:** `RP/0/RSP0/CPU0:router (config-l2vpn-pwc-encap-mpls)# commit`	Saves configuration changes to the running configuration file and remains in the configuration session.

Enabling Multisegment Pseudowires

Use the **pw-status** command after you enable the **pw-status** command. The **pw-status** command is disabled by default. Changing the **pw-status** command reprovisions all pseudowires configured under L2VPN.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **pw-status**
4. **commit**

DETAILED STEPS

	Command	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**l2vpn** **Example:** `RP/0/RSP0/CPU0:router (config)# l2vpn`	Enters Layer 2 VPN configuration mode.
Step 3	**pw-status** **Example:** `RP/0/RSP0/CPU0:router (config-l2vpn)# pw-status`	Enables all pseudowires configured on this Layer 2 VPN. **Note** Use the **pw-status disable** command to disable pseudowire status.
Step 4	**commit** **Example:** `RP/0/RSP0/CPU0:router (config-l2vpn)# commit`	Saves configuration changes to the running configuration file and remains in the configuration session.

Configuring Pseudowire Redundancy

Pseudowire redundancy allows you to configure a backup pseudowire in case the primary pseudowire fails. When the primary pseudowire fails, the PE router can switch to the backup pseudowire. You can elect to have the primary pseudowire resume operation after it becomes functional.

These topics describe how to configure pseudowire redundancy:

- Configuring a Backup Pseudowire, page LSC-145
- Configuring Point-to-Point Pseudowire Redundancy, page LSC-147
- Forcing a Manual Switchover to the Backup Pseudowire, page LSC-149

Configuring a Backup Pseudowire

Perform this task to configure a backup pseudowire for a point-to-point neighbor.

Note When you reprovision a primary pseudowire, traffic resumes in two seconds. However, when you reprovision a backup pseudowire, traffic will resume after a delay of 45 to 60 seconds. This is expected behavior.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **xconnect group** *group-name*
4. **p2p** {*xconnect-name*}
5. **neighbor** {*A.B.C.D*} {**pw-id** *value*}
6. **backup** {**neighbor** *A.B.C.D*} {**pw-id** *value*}
7. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	`configure` **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters configuration mode.
Step 2	`l2vpn` **Example:** `RP/0/RSP0/CPU0:router(config)# l2vpn` `RP/0/RSP0/CPU0:router(config-l2vpn)#`	Enters L2VPN configuration mode.

	Command or Action	Purpose
Step 3	**xconnect group** *group-name* **Example:** `RP/O/RSP0/CPU0:router(config-l2vpn)# xconnect group A` `RP/0/RSP0/CPU0:router(config-l2vpn-xc)#`	Enters the name of the cross-connect group.
Step 4	**p2p** {*xconnect-name*} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p xc1` `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)#`	Enters a name for the point-to-point cross-connect.
Step 5	**neighbor** {*A.B.C.D*} {**pw-id** *value*} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# neighbor 10.1.1.2 pw-id 2`	Configures the pseudowire segment for the cross-connect.
Step 6	**backup** {**neighbor** *A.B.C.D*} {**pw-id** *value*} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# backup neighbor 10.2.2.2 pw-id 5` `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw-backup)#`	Configures the backup pseudowire for the cross-connect. • Use the **neighbor** keyword to specify the peer to cross-connect. The IP address argument (*A.B.C.D*) is the IPv4 address of the peer. • Use the **pw-id** keyword to configure the pseudowire ID. The range is from 1 to 4294967295.
Step 7	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw-backup)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw-backup)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Point-to-Point Pseudowire Redundancy

Perform this task to configure point-to-point pseudowire redundancy for a backup delay.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **pw-class** {*class-name*}
4. **backup disable** {**delay** *value* | **never**}
5. **exit**
6. **xconnect group** *group-name*
7. **p2p** {*xconnect-name*}
8. **neighbor** {*A.B.C.D*} {**pw-id** *value*}
9. **pw-class** {*class-name*}
10. **backup** {**neighbor** *A.B.C.D*} {**pw-id** *value*}
11. **end**
    or
    commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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	**pw-class** {class-*name*} **Example:** `RP/O/RSP0/CPU0:router(config-l2vpn)# pw-class path1` `RP/0/RSP0/CPU0:router(config-l2vpn-pwc)#`	Configures the pseudowire class name.

	Command or Action	Purpose
Step 4	**backup disable** {**delay** *value* | **never**} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-pwc)# backup disable delay 20`	This command specifies how long the primary pseudowire should wait after it becomes active to take over from the backup pseudowire. • Use the **delay** keyword to specify the number of seconds that elapse after the primary pseudowire comes up before the secondary pseudowire is deactivated. The range is from 0 to 180. • Use the **never** keyword to specify that the secondary pseudowire does not fall back to the primary pseudowire if the primary pseudowire becomes available again, unless the secondary pseudowire fails.
Step 5	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-pwc)# exit` `RP/O/RSP0/CPU0:router(config-l2vpn)#`	Exits the current configuration mode.
Step 6	**xconnect group** *group-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group A` `RP/0/RSP0/CPU0:router(config-l2vpn-xc)#`	Enters the name of the cross-connect group.
Step 7	**p2p** {*xconnect-name*} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p xc1` `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)#`	Enters a name for the point-to-point cross-connect.
Step 8	**neighbor** {*A.B.C.D*} {**pw-id** *value*} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# neighbor 10.1.1.2 pw-id 2` `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)#`	Configures the pseudowire segment for the cross-connect.
Step 9	**pw-class** {class-*name*} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# pw-class path1`	Configures the pseudowire class name.

	Command or Action	Purpose
Step 10	**backup** {**neighbor** *A.B.C.D*} {**pw-id** *value*} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# backup neighbor 10.2.2.2 pw-id 5` `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw-backup)#`	Configures the backup pseudowire for the cross-connect. • Use the **neighbor** keyword to specify the peer to the cross-connect. The A.B.C.D argument is the IPv4 address of the peer. • Use the **pw-id** keyword to configure the pseudowire ID. The range is from 1 to 4294967295.
Step 11	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw-backup)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw-backup)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Forcing a Manual Switchover to the Backup Pseudowire

To force the router to switch over to the backup or switch back to the primary pseudowire, use the **l2vpn switchover** command in EXEC mode.

A manual switchover is made only if the peer specified in the command is actually available and the cross-connect moves to the fully active state when the command is entered.

Configuring Preferred Tunnel Path

This procedure describes how to configure a preferred tunnel path.

Note The tunnel used for the preferred path configuration is an MPLS Traffic Engineering (MPLS-TE) tunnel.

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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters the 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 name.
Step 4	**encapsulation mpls** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-pwc)# encapsulation mpls`	Configures the pseudowire encapsulation to MPLS.

	Command or Action	Purpose
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-te 11 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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-pwc-encap-mpls)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-pwc-encap-mpls-if)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring PW Status OAM

Perform this task to configure pseudowire status OAM.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **pw-oam refresh transmit** *seconds*
4. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters the configuration mode.
Step 2	**l2vpn** **Example:** `RP/0/RSP0/CPU0:router(config)# l2vpn`	Enters L2VPN configuration mode.

	Command or Action	Purpose
Step 3	**pw-oam refresh transmit** *seconds* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# pw-oam refresh transmit 100`	Enables pseudowire OAM functionality. **Note** The refresh transmit interval ranges from 1 to 40 seconds.
Step 4	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Enabling Flow-based Load Balancing

Perform this task to enable flow-based load balancing.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **load-balancing flow** {**src-dst-mac** | **src-dst-ip**}
4. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters the 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 for all the pseudowires and bundle EFPs under L2VPN, unless otherwise explicitly specified for pseudowires via pseudowire class and bundles via EFP-hash.
Step 4	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Enabling Flow-based Load Balancing for a Pseudowire Class

Perform this task to enable flow-based load balancing for a pseudowire class.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **pw-class** {*name*}
4. **encapsulation mpls**

5. **load-balancing pw-label**
6. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters the 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 name.
Step 4	**encapsulation mpls** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-pwc)# encapsulation mpls`	Configures the pseudowire encapsulation to MPLS.

	Command or Action	Purpose
Step 5	**load-balancing pw-label** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-pwc-encap-mpls)# load-balancing pw-label`	Enables all pseudowires using the defined class to use virtual circuit based load balancing.
Step 6	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-pwc-encap-mpls)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-pwc-encap-mpls)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Setting Up Your Multicast Connections

Refer to the *Implementing Multicast Routing on Cisco ASR 9000 Series Aggregation Services Routers* module of the *Cisco ASR 9000 Series Aggregation Services Router Multicast Configuration Guide* and the *Multicast Routing and Forwarding Commands on Cisco ASR 9000 Series Aggregation Services Routers* module of the *Cisco ASR 9000 Series Aggregation Services Router Multicast Command Reference*.

SUMMARY STEPS

1. **configure**
2. **multicast-routing**
3. **address-family ipv4**
4. **nsf**
5. **interface all enable**
6. **accounting per-prefix**
7. **router pim**
8. **vrf default address-family ipv4**
9. **rp-address**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**multicast-routing** [**address-family ipv4**] **Example:** `RP/0/RSP0/CPU0:router(config)# multicast-routing`	Enters multicast routing configuration mode. • These multicast processes are started: MRIB, MFWD, PIM, and IGMP. • For IPv4, IGMP version 3 is enabled by default. • For IPv4, use the **address-family ipv4** keywords.
Step 3	**interface all enable** **Example:** `RP/0/RSP0/CPU0:router(config-mcast-ipv4)# interface all enable`	Enables multicast routing and forwarding on all new and existing interfaces.
Step 4	**exit** **Example:** `RP/0/RSP0/CPU0:router(config-mcast-ipv4)# exit`	Exits multicast routing configuration mode, and returns the router to the parent configuration mode.

	Command or Action	Purpose
Step 5	**router igmp** **Example:** `RP/0/RSP0/CPU0:router(config)# router igmp`	(Optional) Enters router IGMP configuration mode.
Step 6	**version** {**1** | **2** | **3**} **Example:** `RP/0/RSP0/CPU0:router(config-igmp)# version 3`	(Optional) Selects the IGMP version that the router interface uses. • The default for IGMP is version 3. • Host receivers must support IGMPv3 for PIM-SSM operation. • If this command is configured in router IGMP configuration mode, parameters are inherited by all new and existing interfaces. You can override these parameters on individual interfaces from interface configuration mode.
Step 7	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-igmp)# end` or `RP/0/RSP0/CPU0:router(config-igmp)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 8	**show pim** [**ipv4**] **group-map** [*ip-address-name*] [**info-source**] **Example:** `RP/0//CPU0:router# show pim ipv4 group-map`	(Optional) Displays group-to-PIM mode mapping.
Step 9	**show pim** [**vrf** *vrf-name*] [**ipv4**] **topology** [*source-ip-address* [*group-ip-address*] | **entry-flag** *flag* | **interface-flag** | **summary**] [**route-count**] **Example:** `RP/0/RSP0/CPU0:router# show pim topology`	(Optional) Displays PIM topology table information for a specific group or all groups.

Configuring AToM IP Interworking

Perform this task to configure AToM IP Interworking.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **xconnect group** *group-name*
4. **p2p** *xconnect-name*
5. **interworking ipv4**
6. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**l2vpn** **Example:** `RP/0/RSP0/CPU0:router(config)# l2vpn`	Enters L2VPN configuration mode.
Step 3	**xconnect group** *group-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group grp_1`	Enters the name of the cross-connect group.
Step 4	**p2p** *xconnect-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p vlan1`	Enters a name for the point-to-point cross-connect.

	Command or Action	Purpose
Step 5	**interworking ipv4** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interworking ipv4`	Configures IPv4 interworking under P2P.
Step 6	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-if)# end` or `RP/0/RP0/CPU0:router(config-if)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Circuit Emulation Over Packet Switched Network

Perform these tasks to configure CEoP:

- Adding CEM attachment circuit to a Pseudowire, page LSC-160
- Associating a Pseudowire Class, page LSC-162
- Enabling Pseudowire Status, page LSC-165
- Configuring a Backup Pseudowire, page LSC-165

Adding CEM attachment circuit to a Pseudowire

Perform this task to add a CEM attachment circuit to a pseudowire.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **xconnect group** *group-name*
4. **p2p** *xconnect-name*
5. **interface** *type interface-path-id*

6. **neighbor** *A.B.C.D* **pw-id** *pseudowire-id*
7. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**l2vpn** **Example:** `RP/0/RSP0/CPU0:router(config)# l2vpn`	Enters L2VPN configuration mode.
Step 3	**xconnect group** *group-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group grp_1`	Enters the name of the cross-connect group.
Step 4	**p2p** *xconnect-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p vlan1`	Enters a name for the point-to-point cross-connect.
Step 5	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface CEM0/1/0/9:10`	Specifies the interface type and instance.

	Command or Action	Purpose
Step 6	**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 11`	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. Optionally, you can disable the control word or set the transport-type to Ethernet or VLAN.
Step 7	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Associating a Pseudowire Class

Perform this task to associate the attachment circuit with a pseudowire class.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **pw-class** *class-name*
4. **encapsulation mpls**
5. **protocol ldp**
6. **end**
7. **xconnect group** *group-name*
8. **p2p** *xconnect-name*
9. **interface** *type interface-path-id*
10. **neighbor** *A.B.C.D* **pw-id** *pseudowire-id*
11. **pw-class** *class-name*

12. **end**
    or
    commit

DETAILED STEPS

	Command	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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 class_cem`	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`	Sets pseudowire encapsulation to MPLS.
Step 5	**protocol ldp** **Example:** `RP/0/RSP0/CPU0:router (config-l2vpn-pwc-encap-mpls)# protocol ldp`	Sets pseudowire signaling protocol to LDP.
Step 6	**end** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-pwc-encap-mpls)# end`	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.

	Command	Purpose
Step 7	**xconnect group** *group-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group grp_1`	Configures a cross-connect group.
Step 8	**p2p** *xconnect-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p vlan1`	Configures a point-to-point cross-connect.
Step 9	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface CEM0/1/0/9:20`	Specifies the interface type and instance.
Step 10	**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 11`	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. Optionally, you can disable the control word or set the transport-type to Ethernet or VLAN.
Step 11	**pw-class** *class-name* **Example:** `RP/0/RSP0/CPU0:router (config-l2vpn-xc-p2p)# pw-class class_cem`	Associates the P2P attachment circuit with the specified pseudowire class.
Step 12	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Enabling Pseudowire Status

Perform this task to enable pseudowire status.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **pw-status**
4. **commit**

DETAILED STEPS

	Command	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**l2vpn** **Example:** `RP/0/RSP0/CPU0:router (config)# l2vpn`	Enters Layer 2 VPN configuration mode.
Step 3	**pw-status** **Example:** `RP/0/RSP0/CPU0:router (config-l2vpn)# pw-status`	Enables all pseudowires configured on this Layer 2 VPN. **Note** Use the **pw-status disable** command to disable pseudowire status.
Step 4	**commit** **Example:** `RP/0/RSP0/CPU0:router (config-l2vpn)# commit`	Saves configuration changes to the running configuration file and remains in the configuration session.

Configuring a Backup Pseudowire

Perform this task to configure a backup pseudowire for a point-to-point neighbor.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **xconnect group** *group-name*
4. **p2p** {*xconnect-name*}
5. **neighbor** {*A.B.C.D*} {**pw-id** *value*}
6. **backup** {**neighbor** *A.B.C.D*} {**pw-id** *value*}

7. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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	**xconnect group** *group-name* **Example:** `RP/O/RSP0/CPU0:router(config-l2vpn)# xconnect group A` `RP/0/RSP0/CPU0:router(config-l2vpn-xc)#`	Enters the name of the cross-connect group.
Step 4	**p2p** {*xconnect-name*} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p xc1` `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)#`	Enters a name for the point-to-point cross-connect.
Step 5	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# interface CEM0/1/0/9:20`	Specifies the interface type and instance.
Step 6	**neighbor** {*A.B.C.D*} {**pw-id** *value*} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p)# neighbor 10.1.1.2 pw-id 11`	Configures the pseudowire segment for the cross-connect.
Step 7	**pw-class** *class-name* **Example:** `RP/0/RSP0/CPU0:router (config-l2vpn-xc-p2p-pw-backup)# pw-class class_cem`	Enters pseudowire class submode, allowing you to define a pseudowire class template.

	Command or Action	Purpose
Step 8	**backup** {**neighbor** *A.B.C.D*} {**pw-id** *value*} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# backup neighbor 10.2.2.2 pw-id 5` `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw-backup)#`	Configures the backup pseudowire for the cross-connect. • Use the **neighbor** keyword to specify the peer to cross-connect. The IP address argument (*A.B.C.D*) is the IPv4 address of the peer. • Use the **pw-id** keyword to configure the pseudowire ID. The range is from 1 to 4294967295.
Step 9	**pw-class** *class-name* **Example:** `RP/0/RSP0/CPU0:router (config-l2vpn-xc-p2p-pw-backup)# pw-class class_cem`	Enters pseudowire class submode, allowing you to define a pseudowire class template.
Step 10	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw-backup)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw-backup)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuration Examples for Point to Point Layer 2 Services

This section includes these configuration examples:

L2VPN Interface Configuration: Example

This example shows how to configure an L2VPN interface:

```
configure
 interface GigabitEthernet0/0/0/0.1 l2transport
  encapsulation dot1q 1
  rewrite ingress pop 1 symmetric
 end
```

Local Switching Configuration: Example

This example shows how to configure Layer 2 local switching:

```
configure
 l2vpn
  xconnect group examples
  p2p example1
  interface TenGigE0/7/0/6.5
  interface GigabitEthernet0/4/0/30
 commit
 end

show l2vpn xconnect group examples
Legend: ST = State, UP = Up, DN = Down, AD = Admin Down, UR = Unresolved,
        SB = Standby, SR = Standby Ready

XConnect                    Segment 1                   Segment 2
Group      Name       ST    Description            ST   Description            ST
------------------------    --------------------------  --------------------------
examples   example1   UP    Te0/7/0/6.5            UP   Gi0/4/0/30             UP
------------------------------------------------------------------------------
```

Point-to-Point Cross-connect Configuration: Examples

This section includes configuration examples for both static and dynamic p2p cross-connects.

Static Configuration

This example shows how to configure a static point-to-point cross-connect:

```
configure
  l2vpn
  xconnect group vlan_grp_1
  p2p vlan1
  interface GigabitEthernet0/0/0/0.1
  neighbor 10.2.1.1 pw-id 1
  mpls static label local 699 remote 890
commit
```

Dynamic Configuration

This example shows how to configure a dynamic point-to-point cross-connect:

```
configure
  l2vpn
  xconnect group vlan_grp_1
  p2p vlan1
  interface GigabitEthernet0/0/0/0.1
  neighbor 10.2.1.1 pw-id 1
commit
```

Inter-AS: Example

This example shows how to set up an AC to AC cross-connect from AC1 to AC2:

```
router-id Loopback0

interface Loopback0
 ipv4 address 10.0.0.5 255.255.255.255
!
interface GigabitEthernet0/1/0/0.1 l2transport
encapsulation dot1q 1
!
!
interface GigabitEthernet0/0/0/3
 ipv4 address 10.45.0.5 255.255.255.0
 keepalive disable
!
interface GigabitEthernet0/0/0/4
 ipv4 address 10.5.0.5 255.255.255.0
 keepalive disable
!
router ospf 100
 log adjacency changes detail
 area 0
  interface Loopback0
  !
  interface GigabitEthernet0/0/0/3
  !
  interface GigabitEthernet0/0/0/4
  !
 !
```

```
!
router bgp 100
 address-family ipv4 unicast
  allocate-label all
 !
 neighbor 10.2.0.5
  remote-as 100
  update-source Loopback0
  address-family ipv4 unicast
  !
  address-family ipv4 labeled-unicast
  !
 !
!
l2vpn
 xconnect group cisco
  p2p cisco1
   interface GigabitEthernet0/1/0/0.1
   neighbor 10.0.1.5 pw-id 101
  !
  p2p cisco2
   interface GigabitEthernet0/1/0/0.2
   neighbor 10.0.1.5 pw-id 102
  !
  p2p cisco3
   interface GigabitEthernet0/1/0/0.3
   neighbor 10.0.1.5 pw-id 103
  !
  p2p cisco4
   interface GigabitEthernet0/1/0/0.4
   neighbor 10.0.1.5 pw-id 104
  !
  p2p cisco5
   interface GigabitEthernet0/1/0/0.5
   neighbor 10.0.1.5 pw-id 105
  !
  p2p cisco6
   interface GigabitEthernet0/1/0/0.6
   neighbor 10.0.1.5 pw-id 106
  !
  p2p cisco7
   interface GigabitEthernet0/1/0/0.7
   neighbor 10.0.1.5 pw-id 107
  !
  p2p cisco8
   interface GigabitEthernet0/1/0/0.8
   neighbor 10.0.1.5 pw-id 108
  !
  p2p cisco9
   interface GigabitEthernet0/1/0/0.9
   neighbor 10.0.1.5 pw-id 109
  !
  p2p cisco10
   interface GigabitEthernet0/1/0/0.10
   neighbor 10.0.1.5 pw-id 110
  !
 !
!
mpls ldp
 router-id Loopback0
 log
  neighbor
 !
 interface GigabitEthernet0/0/0/3
```

```
 !
 interface GigabitEthernet0/0/0/4
 !
!
end
```

L2VPN Quality of Service: Example

This example shows how to attach a service-policy to an L2 interface in port mode:

```
configure
  interface GigabitEthernet 0/0/0/0
  l2transport
  service-policy input pmap_1
commit
```

Pseudowires: Examples

The examples include these devices and connections:

- T-PE1 node has:
  - Cross-connect with an AC interface (facing CE1)
  - Pseudowire to S-PE1 node
  - IP address 209.165.200.225
- T-PE2 node
  - Cross-connect with an AC interface (facing CE2)
  - Pseudowire to S-PE1 node
  - IP address 209.165.200.254
- S-PE1 node
  - Multisegment pseudowire cross-connect with a pseudowire segment to T-PE1 node
  - Pseudowire segment to T-PE2 node
  - IP address 209.165.202.158

Configuring Dynamic Pseudowires at T-PE1 Node: Example

```
RP/0/RSP0/CPU0:T-PE1# configure
RP/0/RSP0/CPU0:T-PE1(config)# l2vpn
RP/0/RSP0/CPU0:T-PE1 (config-l2vpn)# pw-class dynamic_mpls
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-pwc)# encapsulation mpls
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-pwc-encap-mpls)# protocol ldp
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-pwc-encap-mpls)# control-word disable
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-pwc-encap-mpls)# exit
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-pwc)# exit
RP/0/RSP0/CPU0:T-PE1(config-l2vpn)# xconnect group XCON1
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc)# p2p xc1
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p)# description T-PE1 MS-PW to 10.165.202.158
via 10.165.200.254
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p)# interface gigabitethernet 0/1/0/0.1
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p)# neighbor 10.165.200.254 pw-id 100
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p-pw)# pw-class dynamic_mpls
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p-pw)# commit
```

Configuring Dynamic Pseudowires at S-PE1 Node: Example

```
RP/0/RSP0/CPU0:S-PE1# configure
RP/0/RSP0/CPU0:S-PE1(config)# l2vpn
RP/0/RSP0/CPU0:S-PE1(config-l2vpn)# pw-class dynamic_mpls
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc)# encapsulation mpls
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc-encap-mpls)# protocol ldp
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc-encap-mpls)# control-word disable
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc-encap-mpls)# exit
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc)# exit
RP/0/RSP0/CPU0:S-PE1(config-l2vpn)# xconnect group MS-PW1
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc)# p2p ms-pw1
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p)# description S-PE1 MS-PW between
10.165.200.225 and 10.165.202.158
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p)# neighbor 10.165.200.225 pw-id 100
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p-pw)# pw-class dynamic_mpls
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p-pw)# exit
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p)# neighbor 10.165.202.158 pw-id 300
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p-pw)# pw-class dynamic_mpls
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p-pw)# commit
```

Configuring Dynamic Pseudowires at T-PE2 Node: Example

```
RP/0/RSP0/CPU0:T-PE2# configure
RP/0/RSP0/CPU0:T-PE2(config)# l2vpn
RP/0/RSP0/CPU0:T-PE2 (config-l2vpn)# pw-class dynamic_mpls
RP/0/RSP0/CPU0:T-PE2 (config-l2vpn-pwc)# encapsulation mpls
RP/0/RSP0/CPU0:T-PE2 (config-l2vpn-pwc-encap-mpls)# protocol ldp
RP/0/RSP0/CPU0:T-PE2 (config-l2vpn-pwc-encap-mpls)# control-word disable
RP/0/RSP0/CPU0:T-PE2 (config-l2vpn-pwc-encap-mpls)# exit
RP/0/RSP0/CPU0:T-PE2 (config-l2vpn-pwc)# exit
RP/0/RSP0/CPU0:T-PE2(config-l2vpn)# xconnect group XCON1
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc)# p2p xc1
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p)# description T-PE2 MS-PW to 10.165.200.225 via
10.165.200.254
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p)# interface gigabitethernet 0/2/0/0.4
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p)# neighbor 10.165.200.254 pw-id 300
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p-pw)# pw-class dynamic_mpls
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p-pw)# commit
```

Configuring Dynamic Pseudowires and Preferred Paths at T-PE1 Node: Example

```
RP/0/RSP0/CPU0:T-PE1# configure
RP/0/RSP0/CPU0:T-PE1(config)# l2vpn
RP/0/RSP0/CPU0:T-PE1(config-l2vpn)# pw-class dynamic_mpls
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-pwc)# encapsulation mpls
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-pwc-encap-mpls)# protocol ldp
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-pwc-encap-mpls)# control-word disable
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-pwc-encap-mpls)# preferred-path interface tunnel-te
1000
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-pwc-encap-mpls)# exit
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-pwc)# exit
RP/0/RSP0/CPU0:T-PE1(config-l2vpn)# xconnect group XCON1
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc)# p2p xc1
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p)# description T-PE1 MS-PW to 10.165.202.158
via 10.165.200.254
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p)# interface gigabitethernet 0/1/0/0.1
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p)# neighbor 10.165.200.254 pw-id 100
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p-pw)# pw-class dynamic_mpls
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p-pw)# commit
```

Configuring Dynamic Pseudowires and Preferred Paths at S-PE1 Node: Example

```
RP/0/RSP0/CPU0:S-PE1# configure
RP/0/RSP0/CPU0:S-PE1(config)# l2vpn
RP/0/RSP0/CPU0:S-PE1(config-l2vpn)# pw-class dynamic_mpls1
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc)# encapsulation mpls
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc-encap-mpls)# protocol ldp
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc-encap-mpls)# control-word disable
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc-encap-mpls)# preferred-path interface tunnel-te
1000
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc-encap-mpls)# exit
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc)# exit
RP/0/RSP0/CPU0:S-PE1(config-l2vpn)# pw-class dynamic_mpls2
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc)# encapsulation mpls
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc-encap-mpls)# protocol ldp
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc-encap-mpls)# control-word disable
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc-encap-mpls)# preferred-path interface tunnel-te
2000
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc-encap-mpls)# exit
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc)# exit
RP/0/RSP0/CPU0:S-PE1(config-l2vpn)# xconnect group MS-PW1
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc)# p2p ms-pw1
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p)# description S-PE1 MS-PW between
10.165.200.225 and 10.165.202.158
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p)# neighbor 10.165.200.225 pw-id 100
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p-pw)# pw-class dynamic_mpls1
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p-pw)# exit
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p)# neighbor 10.165.202.158 pw-id 300
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p-pw)# pw-class dynamic_mpls2
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p-pw)# commit
```

Configuring Dynamic Pseudowires and Preferred Paths at T-PE2 Node: Example

```
RP/0/RSP0/CPU0:T-PE2# configure
RP/0/RSP0/CPU0:T-PE2(config)# l2vpn
RP/0/RSP0/CPU0:T-PE2(config-l2vpn)# pw-class dynamic_mpls
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-pwc)# encapsulation mpls
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-pwc-encap-mpls)# protocol ldp
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-pwc-encap-mpls)# control-word disable
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-pwc-encap-mpls)# preferred-path interface tunnel-te
2000
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-pwc-encap-mpls)# exit
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-pwc)# exit
RP/0/RSP0/CPU0:T-PE2(config-l2vpn)# xconnect group XCON1
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc)# p2p xc1
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p)# description T-PE2 MS-PW to 10.165.200.225 via
10.165.200.254
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p)# interface gigabitethernet 0/2/0/0.4
```

```
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p)# neighbor 10.165.200.254 pw-id 300
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p-pw)# pw-class dynamic_mpls
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p-pw)# commit
```

Configuring Static Pseudowires at T-PE1 Node: Example

```
RP/0/RSP0/CPU0:T-PE1# configure
RP/0/RSP0/CPU0:T-PE1(config)# l2vpn
RP/0/RSP0/CPU0:T-PE1(config-l2vpn)# xconnect group XCON1
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc)# p2p xc1
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p)# interface gigabitethernet 0/1/0/0.1
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p)# neighbor 10.165.200.254 pw-id 100
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p-pw)# mpls static label local 50 remote 400
RP/0/RSP0/CPU0:T-PE1(config-l2vpn-xc-p2p-pw)# commit
```

Configuring Static Pseudowires at S-PE1 Node: Example

```
RP/0/RSP0/CPU0:S-PE1# configure
RP/0/RSP0/CPU0:S-PE1(config)# l2vpn
RP/0/RSP0/CPU0:S-PE1(config-l2vpn)# xconnect group MS-PW1
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc)# p2p ms-pw1
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p)# neighbor 10.165.200.225 pw-id 100
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p-pw)# mpls static label local 400 remote 50
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p-pw)# exit
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p)# neighbor 10.165.202.158 pw-id 300
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p-pw)# mpls static label local 40 remote 500
RP/0/RSP0/CPU0:S-PE1(config-l2vpn-xc-p2p-pw)# commit
```

Configuring Static Pseudowires at T-PE2 Node: Example

```
RP/0/RSP0/CPU0:T-PE2# configure
RP/0/RSP0/CPU0:T-PE2(config)# l2vpn
RP/0/RSP0/CPU0:T-PE2(config-l2vpn)# xconnect group XCON1
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc)# p2p xc1
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p)# interface gigabitethernet 0/2/0/0.4
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p)# neighbor 10.165.200.254 pw-id 300
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p-pw)# mpls static label local 500 remote 40
RP/0/RSP0/CPU0:T-PE2(config-l2vpn-xc-p2p-pw)# commit
```

Preferred Path: Example

This example shows how to configure preferred tunnel path:

```
configure
 l2vpn
 pw-class path1
  encapsulation mpls
   preferred-path interface tunnel tp 50 fallback disable
```

MPLS Transport Profile: Example

This section provides examples for:

- Configuring Preferred Tunnel Path: Example
- Configuring PW Status OAM: Example

Configuring Preferred Tunnel Path: Example

This sample configuration shows how to configure preferred tunnel path:

```
l2vpn
 pw-class foo
  encapsulation mpls
  preferred-path interface tunnel-tp 100 fallback disable
 commit
```

Configuring PW Status OAM: Example

This sample configuration shows how to configure PW status OAM functionality:

```
l2vpn
 pw-oam refresh transmit 100
 commit
```

Viewing Pseudowire Status: Example

show l2vpn xconnect

```
RP/0/RSP0/CPU0:router# show l2vpn xconnect

Legend: ST = State, UP = Up, DN = Down, AD = Admin Down, UR = Unresolved,
        LU = Local Up, RU = Remote Up, CO = Connected
XConnect                   Segment 1                   Segment 2
Group      Name       ST   Description            ST   Description            ST
------------------------   ------------------------   ------------------------
MS-PW1     ms-pw1     UP   10.165.200.225     100    UP   10.165.202.158      300    UP
------------------------------------------------------------------------------
```

show l2vpn xconnect detail

```
RP/0/RSP0/CPU0:router# show l2vpn xconnect detail
Group MS-PW1, XC ms-pw1, state is up; Interworking none
  PW: neighbor 10.165.200.225, PW ID 100, state is up ( established )
    PW class not set
    Encapsulation MPLS, protocol LDP
    PW type Ethernet VLAN, control word enabled, interworking none
    PW backup disable delay 0 sec
    Sequencing not set
    PW Status TLV in use
        MPLS         Local                          Remote
      ------------ ------------------------------ ------------------------------
      Label        16004                          16006
      Group ID     0x2000400                      0x2000700
      Interface    GigabitEthernet0/1/0/2.2       GigabitEthernet0/1/0/0.3
      MTU          1500                           1500
      Control word enabled                        enabled
      PW type      Ethernet VLAN                  Ethernet VLAN
      VCCV CV type 0x2                            0x2
                   (LSP ping verification)        (LSP ping verification)
      VCCV CC type 0x5                            0x7
                   (control word)                 (control word)
                                                  (router alert label)
                   (TTL expiry)                   (TTL expiry)
    ------------ ---------------------------- --------------------------

    Incoming PW Switching TLVs (Label Mapping message):
      None
     Incoming Status (PW Status TLV and accompanying PW Switching TLV):
      Status code: 0x0 (no fault) in Notification message
     Outgoing PW Switching TLVs (Label Mapping message):
```

```
    Local IP Address: 10.165.200.254 , Remote IP address: 10.165.202.158 , PW ID: 300
    Description: S-PE1 MS-PW between 10.165.200.225 and 10.165.202.158
  Outgoing Status (PW Status TLV and accompanying PW Switching TLV):
    Status code: 0x0 (no fault) in Notification message
    Local IP Address: 10.165.200.254
  Create time: 04/04/2008 23:18:24 (00:01:24 ago)
  Last time status changed: 04/04/2008 23:19:30 (00:00:18 ago)
  Statistics:
    packet totals: receive 0
    byte totals: receive 0
PW: neighbor 10.165.202.158 , PW ID 300, state is up ( established )
  PW class not set
  Encapsulation MPLS, protocol LDP
  PW type Ethernet VLAN, control word enabled, interworking none
  PW backup disable delay 0 sec
  Sequencing not set
  PW Status TLV in use
      MPLS         Local                          Remote
    ------------ ------------------------------ ------------------------------
    Label        16004                          16006
    Group ID     0x2000800                      0x2000200
    Interface    GigabitEthernet0/1/0/0.3       GigabitEthernet0/1/0/2.2
    MTU          1500                           1500
    Control word enabled                        enabled
    PW type      Ethernet VLAN                  Ethernet VLAN
    VCCV CV type 0x2                            0x2
                 (LSP ping verification)        (LSP ping verification)
    VCCV CC type 0x5                            0x7
           (control word)                 (control word)
                                                (router alert label)
                 (TTL expiry)                   (TTL expiry)
    ------------ ------------------------------ ------------------------------
  Incoming PW Switching TLVs (Label Mapping message):
    None
  Incoming Status (PW Status TLV and accompanying PW Switching TLV):
    Status code: 0x0 (no fault) in Notification message
  Outgoing PW Switching TLVs (Label Mapping message):
    Local IP Address: 10.165.200.254 , Remote IP address: 10.165.200.225, PW ID: 100
    Description: S-PE1 MS-PW between 10.165.200.225 and 10.165.202.158
  Outgoing Status (PW Status TLV and accompanying PW Switching TLV):
    Status code: 0x0 (no fault) in Notification message
    Local IP Address: 10.165.200.254
  Create time: 04/04/2008 23:18:24 (00:01:24 ago)
  Last time status changed: 04/04/2008 23:19:30 (00:00:18 ago)
  Statistics:
```

```
      packet totals: receive 0
      byte totals: receive 0
RP/0/RSP0/CPU0:router#
""Show l2vpn xconnect summary": added PW-PW count.
"Show l2vpn forwarding location <> (no change: does not display MS-PWs)
"Show l2vpn forwarding summary location <> (no change: does not display MS-PWs)
```

Configuring Any Transport over MPLS: Example

This example shows you how to configure Any Transport over MPLS (AToM):

```
config
l2vpn
 xconnect group test
 p2p test
 interface POS 0/1/0/0.1
 neighbor 10.1.1.1 pw-id 100
```

Configuring AToM IP Interworking: Example

This example shows you how to configure IP interworking:

```
config
l2vpn
 xconnect group test
 p2p test
 interworking ipv4
```

Configuring Circuit Emulation Over Packet Switched Network: Example

This example shows you how to configure Circuit Emulation Over Packet Switched Network:

Adding CEM Attachment Circuit to PW

```
l2vpn
 xconnect group gr1
  p2p p1
   interface CEM 0/0/0/0:10
   neighbor 3.3.3.3 pw-id 11
   !
  !
```

Associating Pseudowire Class

```
l2vpn
 pw-class class-cem
  encapsulation mpls
   protocol ldp
  !
 !
xconnect group gr1
  p2p p1
   interface CEM0/0/0/0:20
```

```
  neighbor 1.2.3.4 pw-id 11
   pw-class class-cem
  !
```

Enabling Pseudowire Status

```
l2vpn
 pw-status
 commit
```

Disabling Pseudowire Status

```
l2vpn
 pw-status disable
 commit
```

Configuring Backup Pseudowire

```
l2vpn
 pw-status
 pw-class class-cem
  encapsulation mpls
   protocol ldp
  !
 !
 xconnect group gr1
  p2p p1
   interface CEM0/0/0/0:20
   neighbor 1.2.3.4 pw-id 11
    pw-class class-cem
    backup neighbor 9.9.9.9 pw-id 1221
     pw-class class-cem
    !
   !
```

Additional References

For additional information related to implementing MPLS Layer 2 VPN, refer to these.

Related Documents

Related Topic	Document Title
Cisco IOS XR L2VPN commands	*Cisco ASR 9000 Series Aggregation Services Router L2VPN and Ethernet Services Command Reference*
Layer 2 VPNs	*Cisco ASR 9000 Series Aggregation Services Router L2VPN and Ethernet Services Configuration Guide*
MPLS VPNs over IP Tunnels	*Cisco ASR 9000 Series Aggregation Services Router L2VPN and Ethernet Services Configuration Guide*
Getting started material	*Cisco ASR 9000 Series Aggregation Services Router Getting Started Guide*

Standards

Standards[1]	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

1. Not all supported standards are listed.

MIBs

MIBs	MIBs Link
—	To locate and download MIBs using Cisco IOS XR software, use the Cisco MIB Locator found at this URL and choose a platform under the Cisco Access Products menu: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	Title
RFC 4447	*Pseudowire Setup and Maintenance Using the Label Distribution Protocol (LDP)*, April 2006
RFC 4448	*Encapsulation Methods for Transport of Ethernet over MPLS Networks*, April 2006

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport

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) on Cisco ASR 9000 Series Aggregation Services Routers. VPLS supports Layer 2 VPN technology and provides transparent multipoint Layer 2 connectivity for customers.

Note This approach enables service providers to host a multitude of new services such as broadcast TV and Layer 2 VPNs.For more information about MPLS Layer 2 VPN on Cisco ASR 9000 Series Routers and for descriptions of the commands listed in this module, see the "Related Documents" section. To locate documentation for other commands that might appear while executing a configuration task, search online in the Cisco IOS XR software master command index.

Feature History for Implementing Multipoint Layer 2 Services on Cisco ASR 9000 Series Routers

Release	Modification
Release 3.7.2	This feature was introduced on Cisco ASR 9000 Series Routers.
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 4 on page 391 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 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.

Contents

Prerequisites for Implementing Multipoint Layer 2 Services

Before configuring VPLS, 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 VPLS is 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 Virtual Private LAN Services (VPLS), you should understand these concepts:

Virtual Private LAN Services Overview

Virtual Private LAN Service (VPLS) enables 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 VPLS network are described in these sections.

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
- Convergence Mode
- TE FRR Optimized Mode

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.

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.

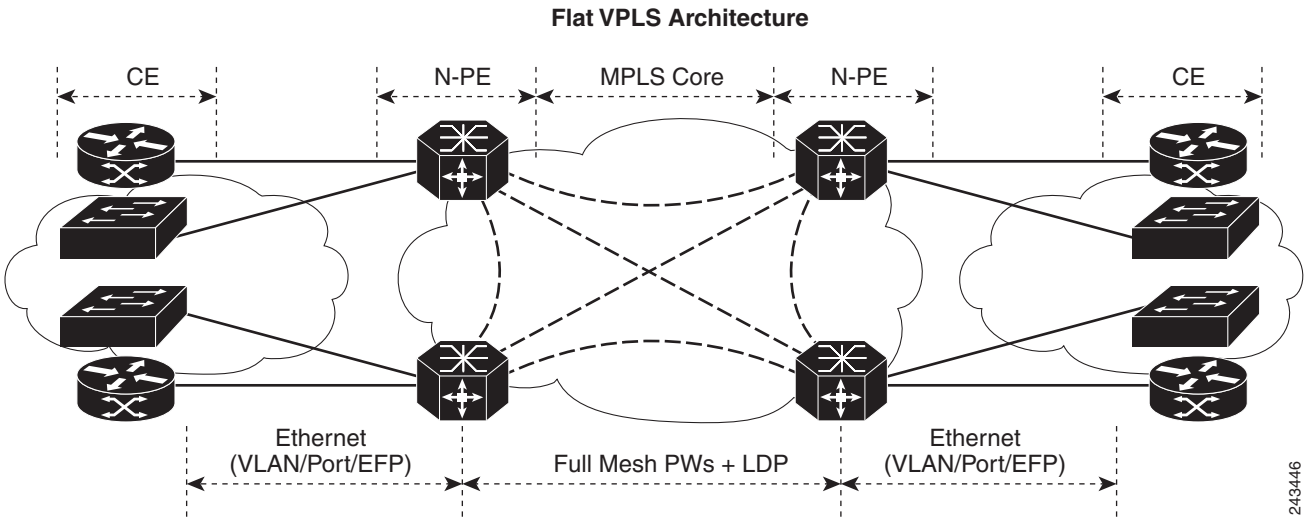
The MPLS/IP provider core simulates a virtual bridge that connects the multiple attachment circuits on each of the PE devices together to form a single broadcast domain. This also requires all of the PE routers that are participating in a VPLS instance to form emulated virtual circuits (VCs) among them.

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.

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. Figure 9 shows a flat VPLS architecture illustrating the interconnection between the network provider edge (N-PE) nodes over an IP/MPLS network.

Figure 9 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.

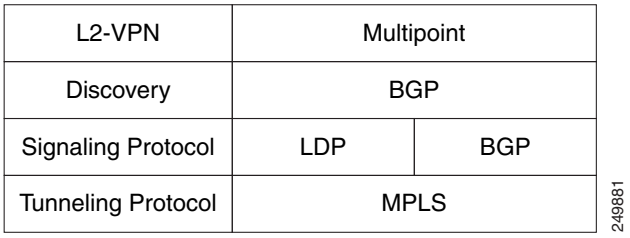
VPLS Discovery and Signaling

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 10 VPLS Autodiscovery and Signaling



BGP-based VPLS Autodiscovery

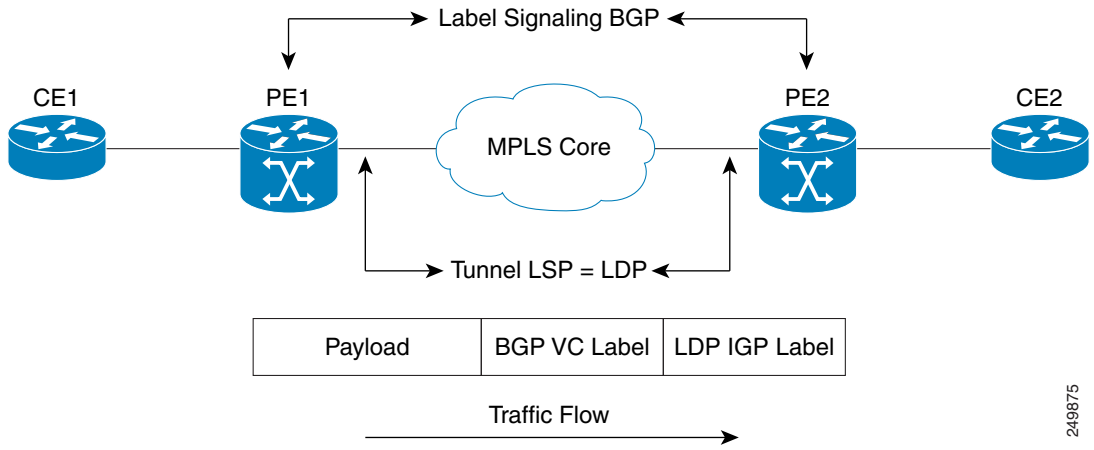
An important aspect of VPN technologies, including VPLS, is the ability of network devices to automatically signal to other devices about an association with a particular VPN. Autodiscovery requires this information to be distributed to all members of a VPN. VPLS is a multipoint mechanism for which BGP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

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 11 Discovery and Signaling Attributes



The BGP signaling and autodiscovery scheme has the following components:

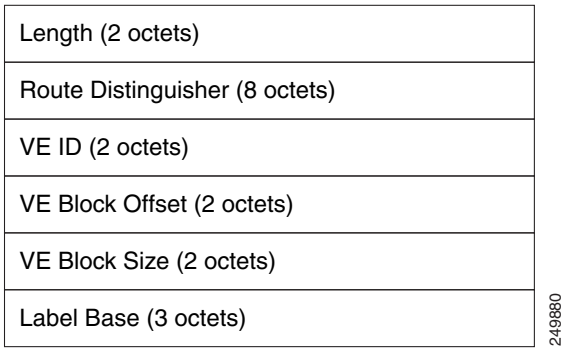
- A means for a PE to learn which remote PEs are members of a given VPLS. This process is known as autodiscovery.
- A means for a PE to learn the pseudowire label expected by a given remote PE for a given VPLS. This process is known as signaling.

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

Figure 12 shows the NLRI format for VPLS with BGP AD and Signaling

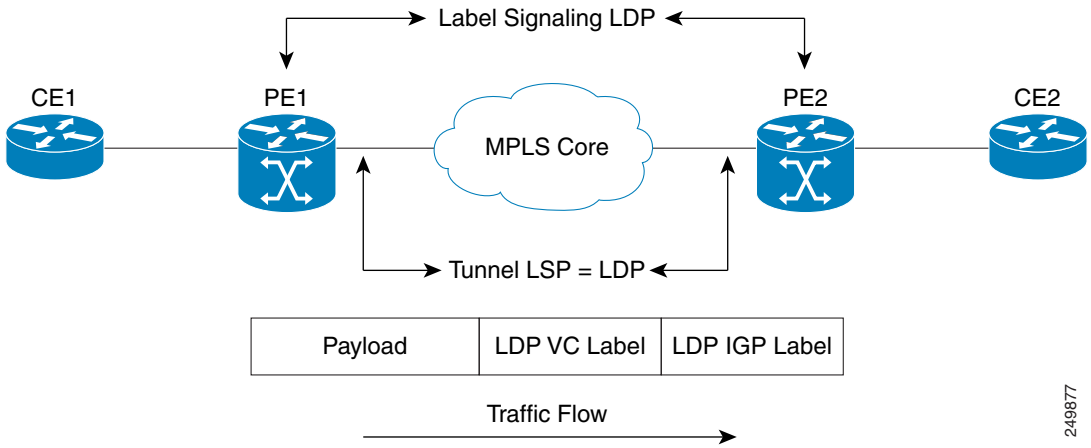
Figure 12 NLRI Format



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 13 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.

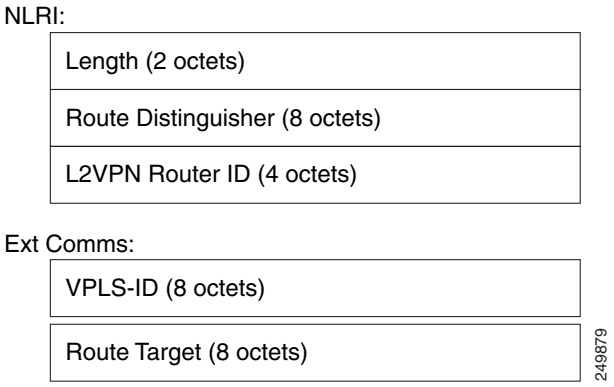
The LDP protocol is used to configure a pseudowire to all the other PE routers. FEC 129 is used for the signaling. The information carried by FEC 129 includes the VPLS ID, the Target Attachment Individual Identifier (TAII) and the Source Attachment Individual Identifier (SAII).

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

Figure 14 depicts Network Layer Reachability Information (NLRI) and extended communities (Ext Comms).

Figure 14 NLRI and Extended Communities



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 distributed. In other words, a copy of the MAC address table is maintained on the route processor (RP) card and the line cards.

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

- MAC Address Flooding, page LSC-194
- MAC Address-based Forwarding, page LSC-194

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 sent to all line cards (LCs) and program the hardware for the router.

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 limit is set at the bridge domain level and at the port level. 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 5-512000.

Note Cisco ASR 9000 Series Routers support MAC limits on bridge port only when they are set on all the ports in a bridge domain. In this case, the bridge domain limit must be set to the value higher than the sum of limits on all ports in the bridge domain.

When the MAC address limit is violated, the system is configured to take one of the actions that are listed in Table 1.

Table 1 MAC Address Limit Actions

Action	Description
Limit flood	Discards the new MAC addresses.
Limit no-flood	Discards the new MAC addresses. Flooding of unknown unicast packets is disabled.
Limit shutdown	Disables forwarding MAC addresses.

When a limit is exceeded, the system is configured to perform these notifications:

- Syslog (default)
- Simple Network Management Protocol (SNMP) trap
- Syslog and SNMP trap
- None (no notification)

To clear the MAC limit condition, the number of MACs must go below 75 percent of the configured limit.

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 and are not propagated over access pseudowires. 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

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 is limited to manually configured VPLS pseudowires (signaled using LDP FEC128). For information about Virtual Circuit Connection Verification (VCCV) support and the **ping mpls pseudowire** command, see the *Cisco ASR 9000 Series Aggregation Services Router MPLS Command Reference*.

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. In general, frames received on one member of a split horizon group are not flooded out to the other members of the same 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. Unicast traffic consists of frames sent to bridge ports that were learned using MAC learning.

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, page LSC-198
- Dynamic Host Configuration Protocol Snooping, page LSC-199

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

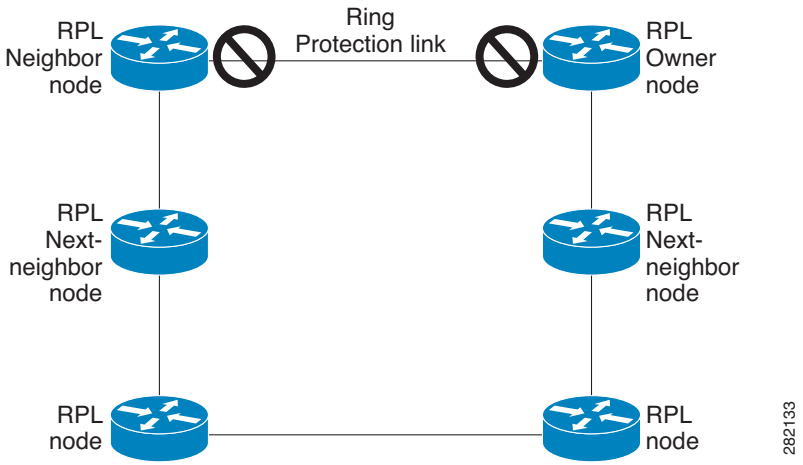
Loop avoidance in an Ethernet ring is achieved by ensuring that, at any time, traffic flows on all but one of the ring links which is the RPL. Multiple nodes are used to form a ring:

- 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.

Figure 15 illustrates the G.8032 Ethernet ring.

Figure 15 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

Figure 16 represents protection switching in case of a single link failure.

Figure 16 G.8032 Single Link Failure

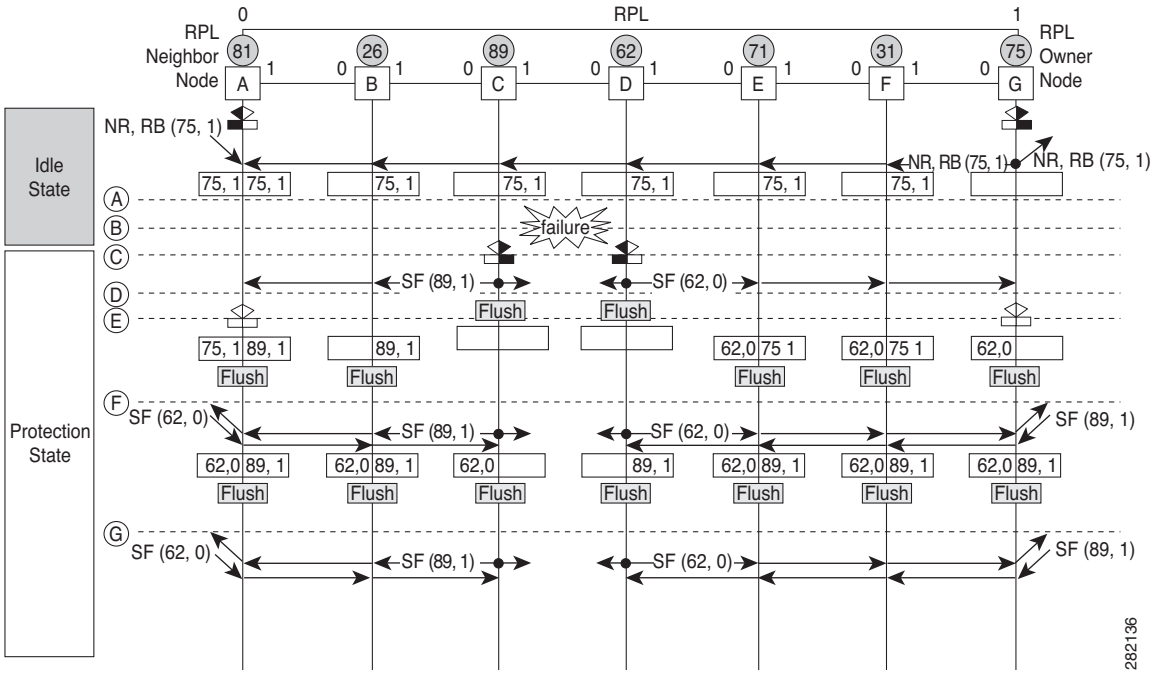
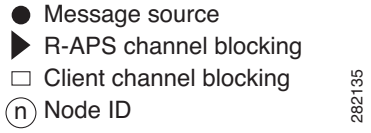


Figure 16 represents an Ethernet ring composed of seven Ethernet ring nodes. The RPL is the ring link between Ethernet ring nodes A and G. In these scenarios, both ends of the RPL are blocked. Ethernet ring node G is the RPL owner node, and Ethernet ring node A is the RPL neighbor node.

These symbols are used:



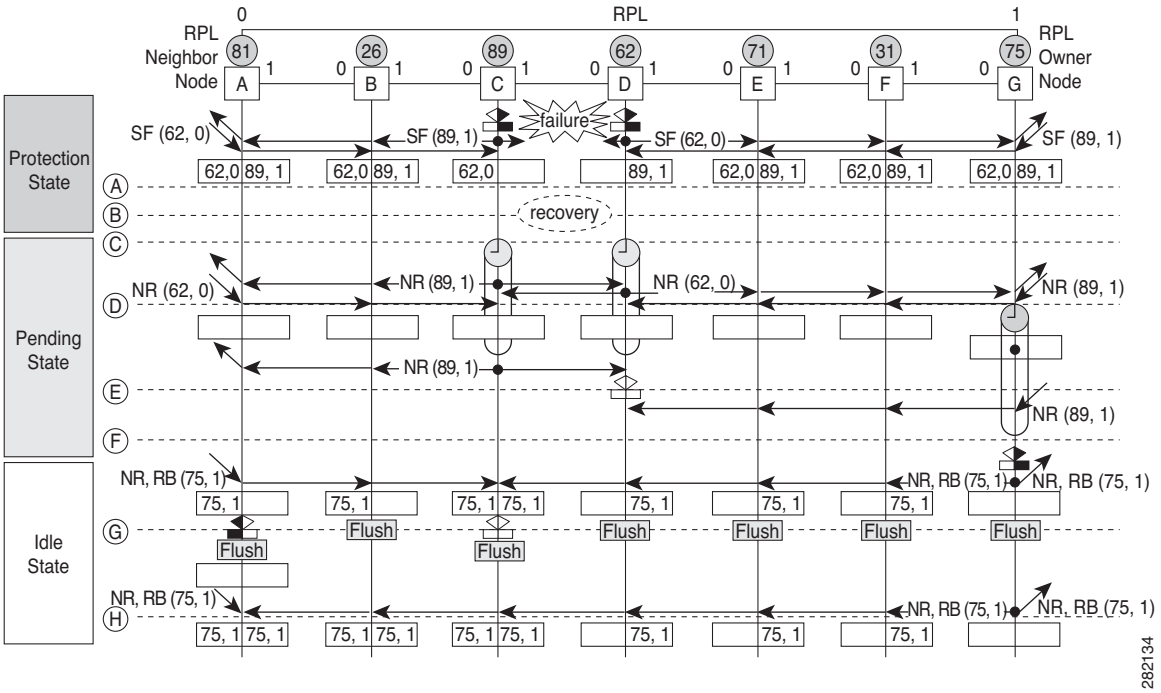
This sequence describes the steps in the single link failure, represented in Figure 16:

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.

Figure 17 represents reversion in case of a single link failure.

Figure 17 Single link failure Recovery (Revertive operation)



This sequence describes the steps in the single link failure recovery, as represented in Figure 17:

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.

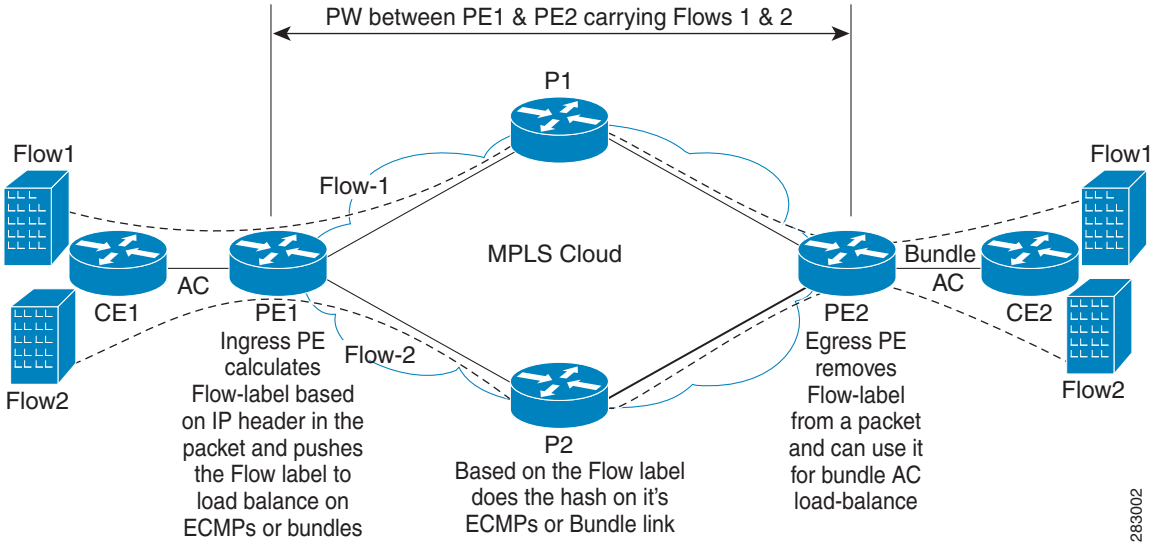
Flow Aware Transport Pseudowire (FAT PW) Overview

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.

Figure 18 shows a FAT PW with two flows distributing over ECMPs and bundle links.

Figure 18 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.

All core routers perform load balancing based on the flow-label in the FAT PW. Therefore, it is possible to distribute flows over ECMPs and link bundles.

How to Implement Multipoint Layer 2 Services

This section describes the tasks that are required to implement VPLS:

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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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. **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.

	Command or Action	Purpose
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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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. **static-mac-address** {*MAC-address*}
7. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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	**static-mac-address** {*MAC-address*} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# 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 7	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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—Enables or disables flooding on the bridge domain. By default, flooding is enabled.
- 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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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`	Configures flooding for traffic at the bridge domain level or at the bridge port level.
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.

	Command or Action	Purpose
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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
Step 5	**shutdown** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#`	Shuts down a bridge domain to bring the bridge and all attachment circuits and pseudowires under it to admin down state.
Step 6	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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.
Step 6	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
Step 5	**security** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# security`	Enables Layer 2 port security on a bridge.
Step 6	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**l2vpn** **Example:** `RP/0/RSP0/CPU0:router(config)# l2vpn` `RP/0/RSP0/CPU0:router(config-l2vpn)#`	Enters L2VPN 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.

	Command or Action	Purpose
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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring a Layer 2 Virtual Forwarding Instance

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

Adding the Virtual Forwarding Instance Under the Bridge Domain

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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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 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 7	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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 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 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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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 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 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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Any Transport over Multiprotocol Pseudowires By 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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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 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 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 access pseudowire configuration. You can set the local and remote pseudowire labels.
Step 8	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-pw)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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. **end**
   or
   commit
8. **show l2vpn bridge-domain** [**detail**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
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:

- Configuring the MAC Address Source-based Learning, page LSC-237
- Enabling the MAC Address Withdrawal, page LSC-240
- Configuring the MAC Address Limit, page LSC-242
- Configuring the MAC Address Aging, page LSC-245
- Disabling MAC Flush at the Bridge Port Level, page LSC-248
- Configuring MAC Address Security, page LSC-250

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-domain-name*
5. **mac**
6. **learning disable**
7. **end**
   or
   commit
8. **show l2vpn bridge-domain** [**detail**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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	**learning disable** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)# learning disable`	Disables MAC learning at the bridge domain level.

	Command or Action	Purpose
Step 7	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
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. **end**
   or
   commit
8. **show l2vpn bridge-domain** [**detail**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 8	**show l2vpn bridge-domain** [**detail**] **Example:** `P/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.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **mac**
6. **limit**
7. **maximum** {*value*}
8. **action** {**flood** | **no-flood** | **shutdown**}
9. **notification** {**both** | **none** | **trap**}
10. **end**
    or
    commit
11. **show l2vpn bridge-domain** [**detail**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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	**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 7	**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 8	**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 9	**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.

	Command or Action	Purpose
Step 10	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac-limit)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac-limit)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 11	**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. **type** {**absolute** | **inactivity**}
9. **end**
   or
   commit
10. **show l2vpn bridge-domain** [**detail**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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 120 to 1000000 seconds. Aging time is counted from the last time that the switch saw the MAC address. The default value is 300 seconds.
Step 8	**type** {**absolute** | **inactivity**} **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac-aging)#` `type absolute`	Configures the type for MAC address aging. • Use the **absolute** keyword to configure the absolute aging type. • Use the **inactivity** keyword to configure the inactivity aging type.

	Command or Action	Purpose
Step 9	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac-aging)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac-aging)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 10	**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, bridge port or access pseudowire levels. 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. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-mac)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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**
8. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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 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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw-mac-secure)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw-mac-secure)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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 for a bridge domain is supported.
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

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
Step 6	**split-horizon group** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pw)# split-horizon group`	Adds this access pseudowire to the 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-pw)# 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 access pseudowire 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.

To locate documentation for the commands used in this configuration, refer to the *Multipoint Layer 2 Services Commands* module in the *Cisco ASR 9000 Series Aggregation Services Router L2VPN and Ethernet Services Command Reference*.

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. **commit**
    or
    end

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
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*} **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.

	Command or Action	Purpose
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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad-sig)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad-sig)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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. **route-id**
4. **bridge group** *bridge-group-name*
5. **bridge-domain** *bridge-domain-name*
6. **vfi** *{vfi-name}*
7. **autodiscovery bgp**
8. **vpn-id** *vpn-id*
9. **rd** {*as-number:nn* | *ip-address:nn* | **auto**}
10. **route-target** {*as-number:nn* | *ip-address:nn* | **export** | **import**}
11. **route-target import** {*as-number:nn* | *ip-address:nn*}

12. **route-target export** {*as-number:nn* | *ip-address:nn*}
13. **signaling-protocol ldp**
14. **vpls-id** {*as-number:nn* | *ip-address:nn*}
15. **commit**
    or
    end

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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 1.1.1.1`	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	**vfi** *{vfi-name}* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# vfi vfi-east`	Enters virtual forwarding instance (VFI) configuration mode.

	Command or Action	Purpose
Step 7	**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 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	**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 10	**route-target** {*as-number:nn*|*ip-address:nn*} **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 11	**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 12	**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 13	**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.

	Command or Action	Purpose
Step 14	**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 15	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad-sig)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad-sig)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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** | **holdoff**} *seconds*
4. **non-revertive**
5. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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.

	Command or Action	Purpose
Step 4	**non-revertive** **Example:** `RP/0/RSP0/CPU0:router(config-g8032-ring-profile)# non-revertive`	Specifies a non-revertive ring instance.
Step 5	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-g8032-ring-profile)# end` or `RP/0/RSP0/CPU0:router(config-g8032-ring-profile)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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** *aps-bridge-domain-name*
5. **interface** *type port0-interface-path-id.subinterface*
6. **interface** *type port1-interface-path-id.subinterface*
7. **bridge-domain** *data-bridge-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 interface-path-id*
18. **port1** {**interface** *type interface-path-id* | **bridge-domain** *bridge-domain-name* | **xconnect** *xconnect-name* | **none**}
19. **end**
    or
    commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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** *bridge-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.

	Command or Action	Purpose
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** *bridge-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.

	Command or Action	Purpose
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 interface-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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-erp-instance-aps)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-erp-instance-aps)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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. **end**
    or
    commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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).

	Command or Action	Purpose
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.

	Command or Action	Purpose
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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-erp)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-erp)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring TCN Propagation

Perform this task to configure topology change notification (TCN) propagation.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **tcn-propagation**
4. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Flow Aware Transport Pseudowire

This section provides information on

- Enabling Load Balancing with ECMP and FAT PW for VPWS
- Enabling Load Balancing with ECMP and FAT PW for VPLS

Enabling Load Balancing with ECMP and FAT PW for VPWS

Perform this task to enable load balancing with ECMP and FAT PW for VPWS.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **load-balancing flow** {**src-dst-mac** | **src-dst-ip**}
4. **pw-class** {*name*}
5. **encapsulation mpls**
6. **load-balancing flow-label** {**both** | **receive** | **transmit**} [**static**]
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** {*name*}
13. **end**
    or
    commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters the 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)# 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.

	Command or Action	Purpose
Step 4	**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 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** | **receive** | **transmit**} [**static**] **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-pwc-encap-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-encap-mpls)#exit`	Exits the pseudowire encapsulation submode and returns the router to the parent configuration mode.
Step 8	**xconnect group** *group-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# xconnect group grp1`	Specifies the name of the cross-connect group.
Step 9	**p2p** *xconnect-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc)# p2p vlan1`	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 GigabitEthernet0/0/0/0.1`	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.

	Command or Action	Purpose
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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-xc-p2p-pw)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

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** | **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** | **receive** | **transmit**} [**static**]

14. **end**
    or
    commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters the 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** | **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.

	Command or Action	Purpose
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.

	Command or Action	Purpose
Step 13	**load-balancing flow-label** {**both**|**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	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad -sig)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-vfi-ad -sig)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuration Examples for Multipoint Layer 2 Services

This section includes these configuration examples:

Virtual Private LAN 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 VPLS provider edge (PE) nodes.

This configuration example shows how to configure PE 1:

```
configure
 l2vpn
  bridge group 1
   bridge-domain PE1-VPLS-A
    GigabitEthernet0/0/0/1
    vfi 1
     neighbor 10.2.2.2 pw-id 1
     neighbor 10.3.3.3 pw-id 1
     !
   !
 interface loopback 0
  ipv4 address 10.1.1.1 255.255.255.25
```

This configuration example shows how to configure PE 2:

```
configure
 l2vpn
  bridge group 1
   bridge-domain PE2-VPLS-A
```

```
    interface GigabitEthernet0/0/0/1

    vfi 1
     neighbor 10.1.1.1 pw-id 1
     neighbor 10.3.3.3 pw-id 1
     !
   !
 interface loopback 0
  ipv4 address 10.2.2.2 255.255.255.25
```

This configuration example shows how to configure PE 3:

```
configure
 l2vpn
  bridge group 1
   bridge-domain PE3-VPLS-A
    interface GigabitEthernet0/0/0/1
    vfi 1
     neighbor 10.1.1.1 pw-id 1
     neighbor 10.2.2.2 pw-id 1
     !
   !
 interface loopback 0
  ipv4 address 10.3.3.3 255.255.255.25
```

Virtual Private LAN Services Configuration for Provider Edge-to-Customer Edge: Example

This configuration shows how to configure VPLS for a PE-to-CE nodes:

```
configure
 interface GigabitEthernet0/0/0/1
  l2transport---AC interface

  no ipv4 address
  no ipv4 directed-broadcast
  negotiation auto
  no cdp enable


configure
 interface GigabitEthernet0/0
  l2transport

  no ipv4 address
  no ipv4 directed-broadcast
  negotiation auto
  no cdp enable


configure
 interface GigabitEthernet0/0
  l2transport

  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

Bridge group: siva_group, bridge-domain: siva_bd, id: 0, state: up, ShgId: 0, MSTi: 0
  MAC Learning: enabled
  MAC withdraw: enabled
  Flooding:
    Broadcast & Multicast: enabled
    Unknown Unicast: enabled
  MAC address aging time: 300 s Type: inactivity
  MAC address limit: 4000, Action: none, Notification: syslog
  MAC limit reached: no
  Security: disabled
  DHCPv4 Snooping: disabled
  MTU: 1500
  MAC Filter:  Static MAC addresses:
  ACs: 1 (1 up), VFIs: 1, PWs: 2 (1 up)
  List of ACs:
    AC: GigabitEthernet0/4/0/1, state is up
      Type Ethernet
      MTU 1500; XC ID 0x5000001; interworking none; MSTi 0 (unprotected)
      MAC Learning: enabled
      MAC withdraw: disabled
      Flooding:
        Broadcast & Multicast: enabled
        Unknown Unicast: enabled
      MAC address aging time: 300 s Type: inactivity
      MAC address limit: 4000, Action: none, Notification: syslog
      MAC limit reached: no
      Security: disabled
      DHCPv4 Snooping: disabled
      Static MAC addresses:
      Statistics:
        packet totals: receive 6,send 0
        byte totals: receive 360,send 4
  List of Access PWs:
  List of VFIs:
    VFI siva_vfi
      PW: neighbor 10.1.1.1, PW ID 1, state is down ( local ready )
        PW class not set, XC ID 0xff000001
        Encapsulation MPLS, protocol LDP
        PW type Ethernet, control word enabled, interworking none
        PW backup disable delay 0 sec
        Sequencing not set
                MPLS         Local                          Remote
          ------------ ------------------------------ -------------------------
               Label        30005                          unknown
               Group ID     0x0                            0x0
               Interface    siva/vfi                       unknown
               MTU          1500                           unknown
               Control word  enabled                       unknown
               PW type       Ethernet                      unknown
          ------------ ------------------------------ -------------------------
        Create time: 19/11/2007 15:20:14 (00:25:25 ago)
        Last time status changed: 19/11/2007 15:44:00 (00:01:39 ago)
        MAC withdraw message: send 0 receive 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)

This 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
```

This example shows how to disable the MAC flush at the bridge port level:

```
configure
  l2vpn
    bridge-group group1
    bridge-domain domain1
    interface GigabitEthernet 0/1/0/1
    mac
    port-down flush disable
  end
```

This example shows how to disable the MAC flush at the access pseudowire level:

```
configure
  l2vpn
    bridge-group group1
    bridge-domain domain1
    neighbor 10.1.1.1 pw-id 1000
    mac
    port-down flush disable
   end
```

Bridging on IOS XR Trunk Interfaces: Example

This example shows how to configure a Cisco ASR 9000 Series Router 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 Cisco ASR 9000 Series Router 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 all the line cards of the 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 Access PWs:
  List of VFIs:
RP/0/RSP0/CPU0:router#
```

This table lists the configuration steps (actions) and the corresponding purpose for this example:

	Command or Action	Purpose
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.

	Command or Action	Purpose
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	`end` or `commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Bridging on Ethernet Flow Points: Example

This example shows how to configure a Cisco ASR 9000 Series Router 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 when a line card is inserted. 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, or interfaces for which no line card has been inserted (**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 Access PWs:
  List of VFIs:
RP/0/RSP1/CPU0:router#
```

This table lists the configuration steps (actions) and the corresponding purpose for this example:

	Command or Action	Purpose
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.

	Command or Action	Purpose
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	`end` or `commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Changing the Flood Optimization Mode: Example

This example shows how to change the default flood optimization mode under a bridge domain:

```
config
l2vpn
  bridge group MyGroup
  bridge-domain MyDomain
  flood mode convergence-optimized
```

Configuring VPLS with BGP Autodiscovery and Signaling: Example

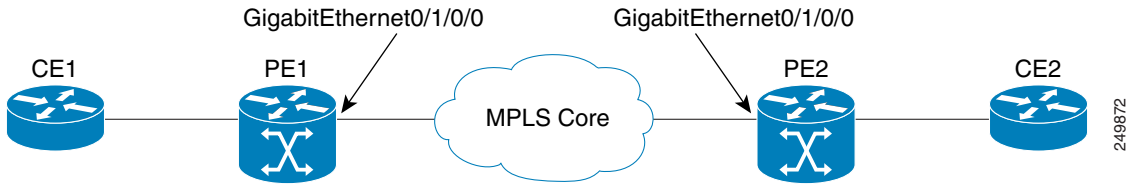
This section contains these configuration examples for configuring the BGP autodiscovery and signaling feature:

- LDP and BGP Configuration
- Minimum L2VPN Configuration for BGP Autodiscovery with BGP Signaling
- VPLS with BGP Autodiscovery and BGP Signaling
- Minimum Configuration for BGP Autodiscovery with LDP Signaling
- VPLS with BGP Autodiscovery and LDP Signaling

LDP and BGP Configuration

Figure 19 illustrates an example of LDP and BGP configuration.

Figure 19 LDP and BGP Configuration



Configuration at PE1:

```
interface Loopback0
    ipv4 address 1.1.1.100 255.255.255.255
!
interface Loopback1
    ipv4 address 1.1.1.10 255.255.255.255
!
mpls ldp
    router-id 1.1.1.1
    interface GigabitEthernt0/1/0/0
!
router bgp 120
    address-family l2vpn vpls-vpws
!
    neighbor 2.2.2.20
    remote-as 120
    update-source Loopback1
    address-family l2vpn vpls-vpws
    signaling bgp disable
```

Configuration at PE2:

```
interface Loopback0
    ipv4 address 2.2.2.200 255.255.255.255
!
interface Loopback1
    ipv4 address 2.2.2.20 255.255.255.255
!
mpls ldp
    router-id 2.2.2.2
    interface GigabitEthernt0/1/0/0
!
router bgp 120
```

```
    address-family l2vpn vpls-vpws
!
    neighbor 1.1.1.10
    remote-as 120
    update-source Loopback1
    address-family l2vpn vpls-vpws
```

Minimum L2VPN Configuration for BGP Autodiscovery with BGP Signaling

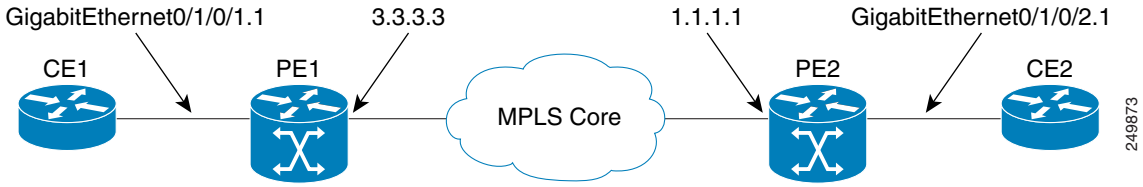
This example illustrates the minimum L2VPN configuration required for BGP Autodiscovery with BGP Signaling, where any parameter that has a default value is not configured.

```
(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 1.1.1.1:100
(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

Figure 20 illustrates an example of configuring VPLS with BGP autodiscovery (AD) and BGP Signaling.

Figure 20 VPLS with BGP autodiscovery and BGP signaling



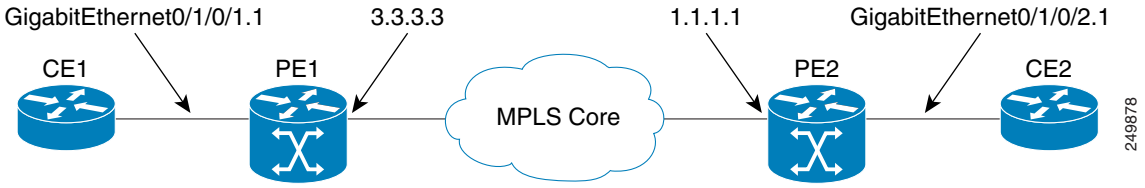
Configuration at PE1:

```
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

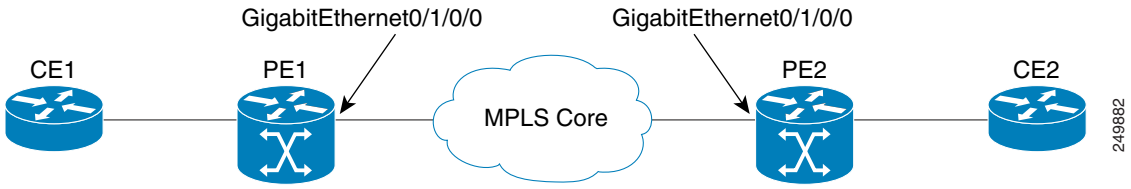
This example illustrates the minimum L2VPN configuration required for BGP Autodiscovery with LDP Signaling, where any parameter that has a default value is not configured.

```
(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

Figure 21 illustrates an example of configuring VPLS with BGP autodiscovery (AD) and LDP Signaling.

Figure 21 VPLS with BGP autodiscovery and LDP signaling



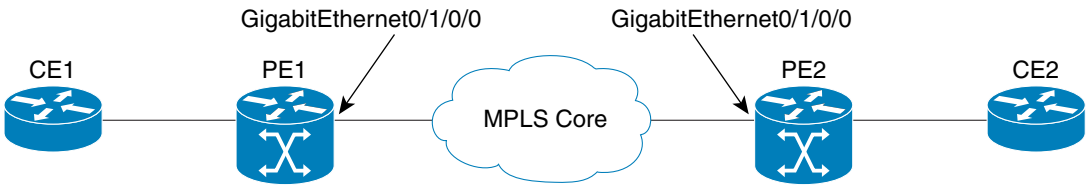
Configuration at PE1:

```
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 - 1.1.1.1
BGP Router ID - 1.1.1.100
Peer Address - 1.1.1.10
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 - 2.2.2.2
BGP Router ID - 2.2.2.200
Peer Address - 2.2.2.20
L2VPN Router ID - 20.20.20.20
Route Distinguisher - 2:200
```

Discovery Attributes

NLRI sent at PE1:

```
Source Address - 1.1.1.10
Destination Address - 2.2.2.20
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 - 2.2.2.20
Destination Address - 1.1.1.10
Length - 14
Route Distinguisher - 2:200
L2VPN Router ID - 20.20.20.20
VPLS ID - 120:100
Route Target - 12:12
```

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:

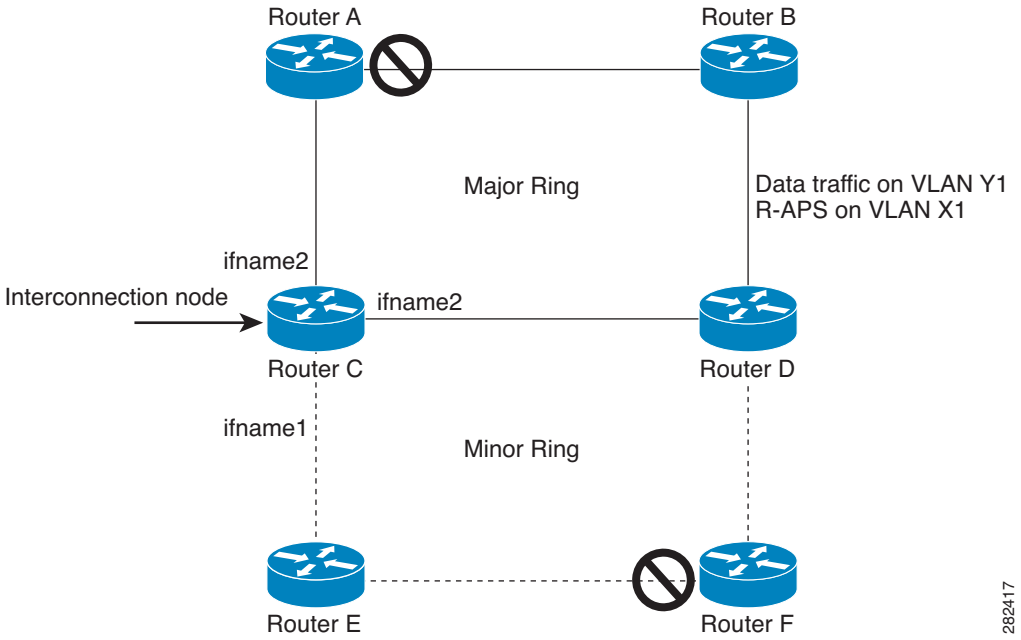
```
# Configure the ERP profile characteristics if ERP instance behaviors are non-default.
ethernet ring g8032 profile ERP-profile
  timer wtr 60
  timer guard 100
  timer hold-off 1
  non-revertive

# 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. Figure 22 illustrates an open ring scenario.

Figure 22 Open Ring Scenario - interconnection node



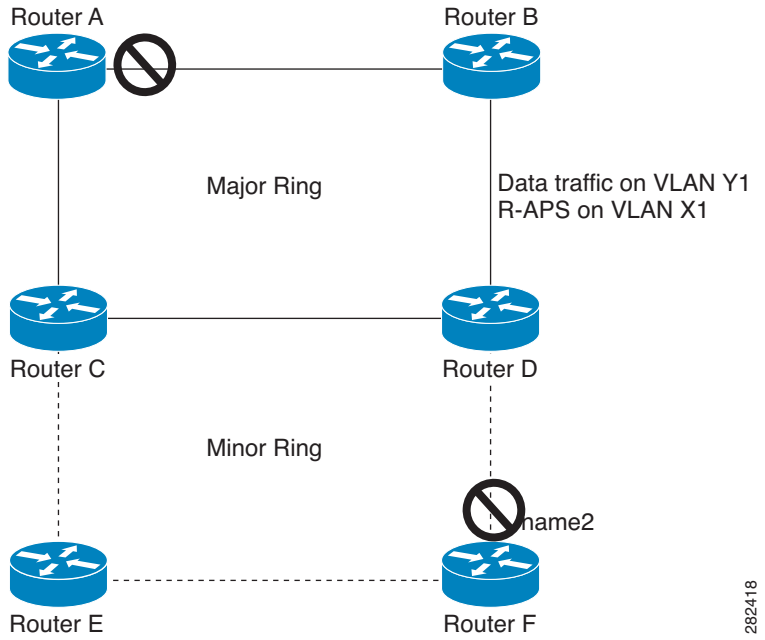
The minimum configuration required for configuring G.8032 at Router C (Open ring – Router C):

```
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. Figure 23 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 GigabitEthernet 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
               !
            !
        !
    !
!
```

Additional References

For additional information related to implementing VPLS, refer to these:

Related Documents

Related Topic	Document Title
Cisco IOS XR L2VPN commands	*Point to Point Layer 2 Services Commands* module in the *Cisco ASR 9000 Series Aggregation Services Router L2VPN and Ethernet Services Command Reference*
MPLS VPLS-related commands	*Multipoint Layer 2 Services Commands* module in the *Cisco ASR 9000 Series Aggregation Services Router L2VPN and Ethernet Services Command Reference*
Getting started material	*Cisco ASR 9000 Series Aggregation Services Router Getting Started Guide*
Traffic storm control on VPLS bridges	*Traffic Storm Control under VPLS Bridges on Cisco ASR 9000 Series Routers* module in the *Cisco ASR 9000 Series Aggregation Services Router System Security Configuration Guide*
Layer 2 multicast on VPLS bridges	*Layer 2 Multicast Using IGMP Snooping* module in the *Cisco ASR 9000 Series Aggregation Services Router Multicast Configuration Guide*

Standards

Standards[1]	Title
draft-ietf-l2vpn-vpls-ldp-09	*Virtual Private LAN Services Using LDP*

1. Not all supported standards are listed.

MIBs

MIBs	MIBs Link
—	To locate and download MIBs using Cisco IOS XR software, use the Cisco MIB Locator found at this URL and choose a platform under the Cisco Access Products menu: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	Title
RFC 4447	*Pseudowire Setup and Maintenance Using the Label Distribution Protocol (LDP)*, April 2006
RFC 4448	*Encapsulation Methods for Transport of Ethernet over MPLS Networks*, April 2006
RFC 4762	*Virtual Private LAN Service (VPLS) Using Label Distribution Protocol (LDP) Signaling*

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport

Implementing IEEE 802.1ah Provider Backbone Bridge

This module provides conceptual and configuration information for IEEE 802.1ah Provider Backbone Bridge on Cisco ASR 9000 Series Routers. The IEEE 802.1ah standard (Ref [4]) provides a means for interconnecting multiple provider bridged networks to build a large scale end-to-end Layer 2 provider bridged network.

Feature History for Implementing IEEE 802.1ah Provider Backbone Bridge

Release	Modification
Release 3.9.1	This feature was introduced on Cisco ASR 9000 Series Routers.

Contents

Prerequisites for Implementing 802.1ah Provider Backbone Bridge

This prerequisite applies to implementing 802.1ah Provider Backbone Bridge:

- 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.
- You must be familiar with the multipoint bridging concepts. Refer to the Implementing Multipoint Layer 2 Services module.

Information About Implementing 802.1ah Provider Backbone Bridge

To implement 802.1ah, you must understand these concepts:

- Benefits of IEEE 802.1ah standard, page 304
- IEEE 802.1ah Standard for Provider Backbone Bridging Overview, page 305
- Backbone Edge Bridges, page 307
- IB-BEB, page 308

Benefits of IEEE 802.1ah standard

The benefits of IEEE 802.1ah provider backbone bridges are as follows:

- Increased service instance scalability
- MAC address scalability

IEEE 802.1ah Standard for Provider Backbone Bridging Overview

The IEEE 802.1ah Provider Backbone Bridge feature encapsulates or decapsulates end-user traffic on a Backbone Edge Bridge (BEB) at the edge of the Provider Backbone Bridged Network (PBBN). A Backbone Core Bridge (BCB) based network provides internal transport of the IEEE 802.1ah encapsulated frames within the PBBN. Figure 24 shows a typical 802.1ah PBB network.

Figure 24 IEEE 802.1ah Provider Backbone Bridge

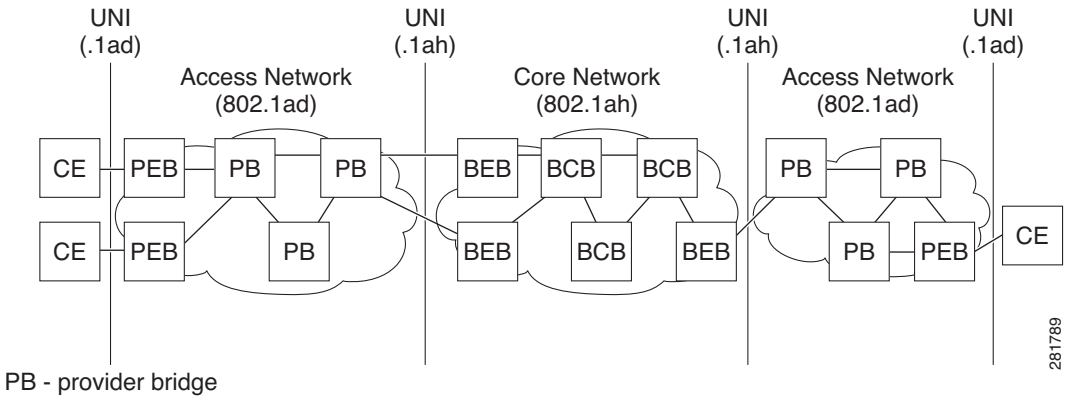
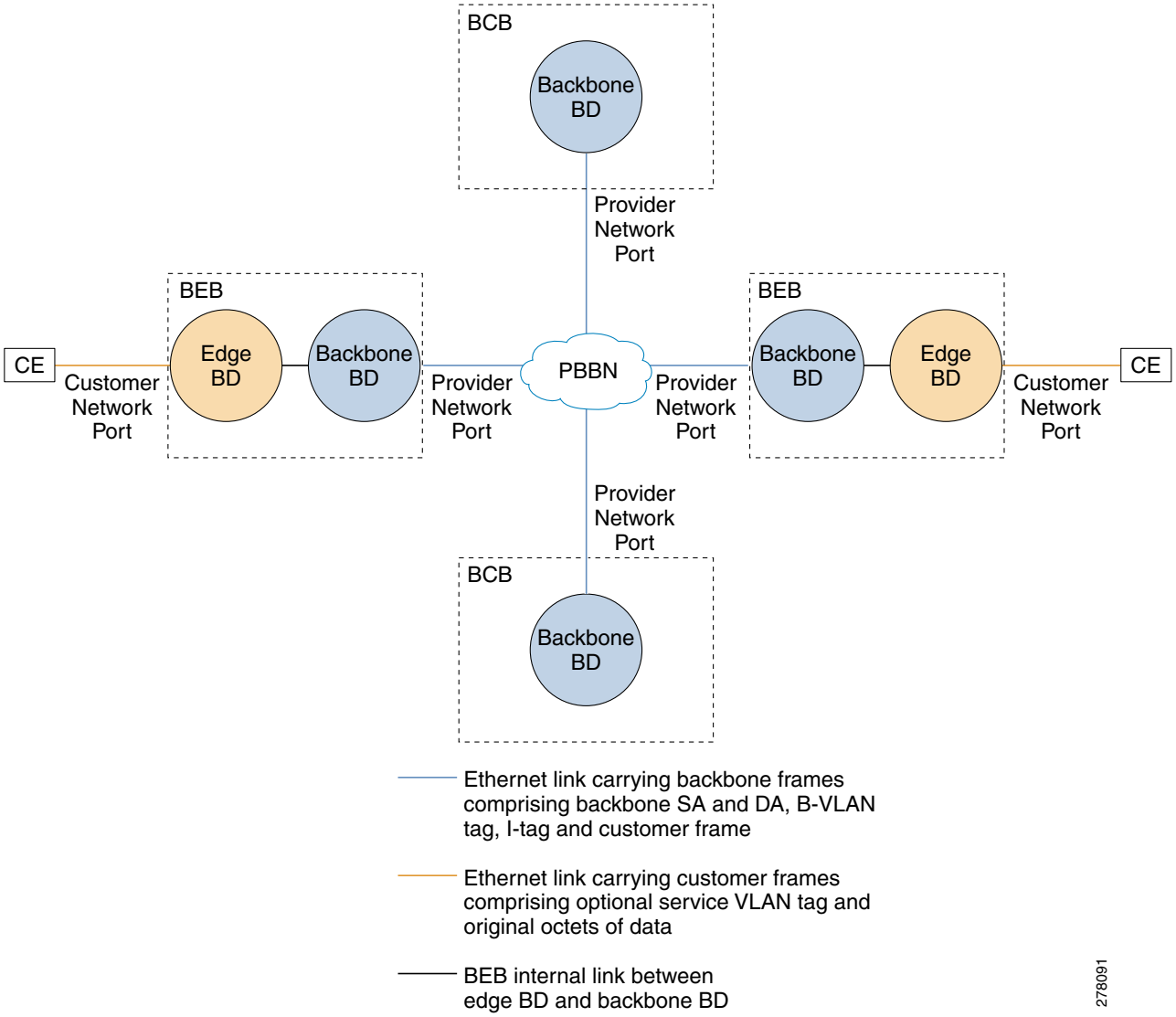


Figure 25 shows a typical provider backbone network topology.

Figure 25 Provider Back Bone Network Topology



Backbone Edge Bridges

Backbone edge bridges (BEBs) can contain either an I-Component or a B-Component. The I-Component maps service VLAN identifiers (S-VIDs) to service instance identifiers (I-SIDs) and adds a provider backbone bridge (PBB) header without a backbone VLAN tag (B-Tag). The B-Component maps I-SIDs to backbone VIDs (B-VIDs) and adds a PBB header with a B-Tag.

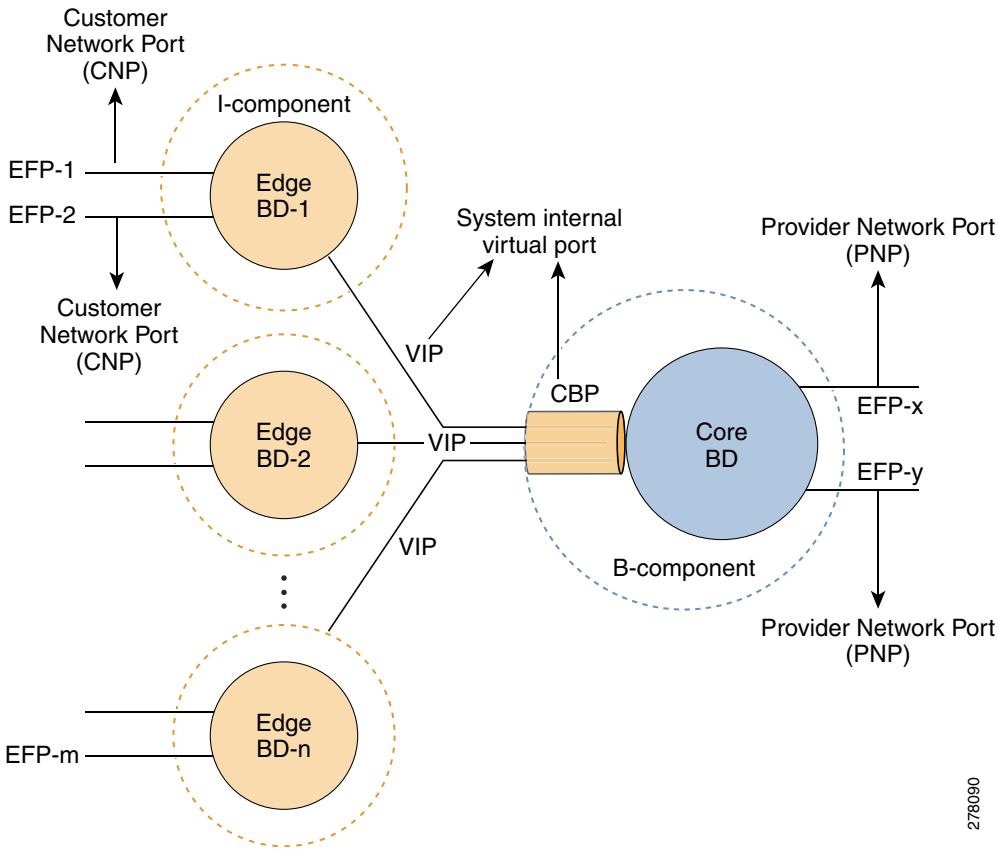
The IEEE 802.1ah standard specifies these three types of BEBs:

- The B-BEB contains the B-Component of the MAC-in-MAC bridge. It validates the I-SIDs and maps the frames onto the backbone VLAN (B-VLAN). It also switches traffic based on the B-VLANS within the core bridge.
- The I-BEB contains the I-Component of the MAC-in-MAC bridge. It performs B-MAC encapsulation and inserts the I-SIDs based on the provider VLAN tags (S-tags), customer VLAN tags (C-tags), or S-tag/C-tag pairs.
- The IB-BEB contains one or more I-Components and a single B-Component interconnected through a LAN segment.

Note Only IB-BEBs are supported on Cisco ASR 9000 Series Routers. Cisco IOS XR supports IB-BEB bridge type at the Edge node.

Figure 26 shows the PBB bridge component topology on the Cisco ASR 9000 Series Routers.

Figure 26 PBB Bridge Component Topology on Cisco ASR 9000 Series Routers



IB-BEB

The IB-BEB contains both the I-Component and the B-Component. The bridge selects the B-MAC and inserts the I-SID based on the provider VLAN tag (S-tag), the customer VLAN tag (C-tag), or both the S-tag and the C-tag. It validates the I-SIDs and it transmits and receives frames on the B-VLAN.

The IEEE 802.1ah on Provider Backbone Bridges feature supports all services mandated by the IEEE 802.1ah standard and extends the services to provides these additional functionalities:

- S-Tagged Service:
  - In multiplexed environments each S-tag maps to an I-SID and may be retained or removed.
  - In bundled environments multiple S-tags map to the same I-SID and the S-tags must be retained.
- C-Tagged Service:
  - In multiplexed environments each C-tag maps to an I-SID and may be retained or removed.
  - In bundled environments multiple C-tags map to the same I-SID and the C-tags must be retained.
- S/C-Tagged Service:
  - In multiplexed environments each S-tag/C-tag pair maps to an I-SID. The S-tag or the S-tag/C-tag pair may be retained or removed.
  - In bundled environments multiple S-tag/C-tags pairs map to the same I-SID and the S-tag/C-tag pair must be retained.
- Port-based Service
  - A port-based service interface is delivered on a Customer Network Port (CNP). A port-based service interface may attach to a C-VLAN Bridge, 802.1d bridge, router or end-station. The service provided by this interface forwards all frames without an S-Tag over the backbone on a single backbone service instance. A port-based interface discards all frames with an S-Tag that have non-null VLAN IDs.

    This example shows how to configure a port-based service:

    ```
    interface GigabitEthernet0/0/0/10.100 l2transport
    encapsulation untagged
    ```
    --> Creates an EFP for untagged frames.

    ```
    interface GigabitEthernet0/0/0/10.101 l2transport
    encapsulation dot1ad priority-tagged
    ```
    --> Creates an EFP for null S-tagged frames.

    ```
    interface GigabitEthernet0/0/0/10.102 l2transport
    encapsulation dot1q priority-tagged
    ```
    --> Creates an EFP for null C-tagged frames:

    ```
    interface GigabitEthernet0/0/0/10.103 l2transport
    encapsulation dot1q any
    ```
    --> Creates an EFP for C-tagged frames:

Note To configure a port-based service, all the above EFPs must be added to the same edge bridge domain.

How to Implement 802.1ah Provider Backbone Bridge

This section contains these procedures:

Restrictions for Implementing 802.1ah Provider Backbone Bridge

These features are not supported:

- Cross-connect based point to point services over MAC-in-MAC
- One Edge bridge to multiple Core bridge mapping
- I type backbone edge bridge (I-BEB) and B type backbone edge bridge (B-BEB)
- IEEE 802.1ah over VPLS
- Multiple source B-MAC addresses per chassis
- Direct encapsulation of 802.1ah formatted packets natively over an MPLS LSP encapsulation

Configuring Ethernet Flow Points on CNP and PNP Ports

Perform this task to configure an Ethernet flow point (EFP) on the customer network port (CNP) or the provider network port (PNP).

SUMMARY STEPS

1. **configure**
2. **interface** *type interface-path-id.subinterface* **l2transport**
3. **encapsulation dot1q** *vlan-id*
   or
   encapsulation dot1ad *vlan-id*
   or
   encapsulation dot1ad *vlan-id* **dot1q** *vlan-id*
4. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface** *type interface-path-id.subinterface* **l2transport** **Example:** `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet0/0/0/10.100 l2transport`	Configures an interface for L2 switching.
Step 3	**encapsulation dot1q** *vlan-id* or **encapsulation dot1ad** *vlan-id* or **encapsulation dot1ad** *vlan-id* **dot1q** *vlan-id* **Example:** `RP/0/RSP0/CPU0:router(config-subif)#` `encapsulation dot1q 100` `or` `encapsulation dot1ad 100` `or` `encapsulation dot1ad 100 dot1q 101`	Assigns the matching VLAN ID and Ethertype to the interfac
Step 4	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-subif)# end` or `RP/0/RSP0/CPU0:router(config-subif)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring PBB Edge Bridge Domain and Service Instance ID

Perform this task to configure a PBB edge domain and the service ID.

Note To configure the PBB feature, login with admin user privileges and issue the **hw-module profile feature l2** command to select an ASR 9000 Ethernet line card ucode version that supports the PBB feature. The PBB feature will not be supported on the ASR 9000 Ethernet line card unless you make this configuration. For more information on configuring the feature profile, refer to the *Cisco ASR 9000 Series Aggregation Services Router System Management Configuration Guide*.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *group-name*
4. **bridge-domain** *domain-name*
5. **interface** *type interface-path-id.subinterface*
6. **pbb edge i-sid** service-id **core-bridge** *core-bridge-name*
7. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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 pbb`	Enters configuration mode for the named bridge group. This command creates a new bridge group or modifies the existing bridge group if it already exists. A bridge group organizes bridge domains.
Step 4	**bridge-domain** *domain-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg)#bridge-domain pbb-edge`	Enters configuration mode for the named bridge domain. This command creates a new bridge domain or modifies the existing bridge domain, if it already exists.

	Command or Action	Purpose
Step 5	**interface** type interface-path-id.subinterface **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#interface GigabitEthernet0/5/0/0.20`	Assigns the matching VLAN ID and Ethertype to the interface. This EFP is considered as the CNP for the Edge bridge.
Step 6	**pbb edge i-sid** *service-id* **core-bridge** *core-bridge-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# pbb edge i-sid 1000 core-bridge pbb-core`	Configures the bridge domain as PBB edge with the service identifier and the assigned core bridge domain, and enters the PBB edge configuration submode. This command also creates the Virtual instance port (VIP) that associates the PBB Edge bridge domain to the specified Core bridge domain. All the interfaces (bridge ports) under this bridge domain are treated as the customer network ports (CNP).
Step 7	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pbb-edge)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pbb-edge)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring the PBB Core Bridge Domain

Perform this task to configure the PBB core bridge domain.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *group-name*
4. **bridge-domain** *domain-name*
5. **interface** *type interface-path-id.subinterface*
6. **pbb core**
7. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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 pbb`	Enters configuration mode for the named bridge group. This command creates a new bridge group or modifies the existing bridge group, if it already exists. A bridge group organizes bridge domains.
Step 4	**bridge-domain** *domain-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg)#bridge-domain pbb-core`	Enters configuration mode for the named bridge domain. This command creates a new bridge domain or modifies the existing bridge domain if it already exists.
Step 5	**interface** type interface-path-id.subinterface **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#interface GigabitEthernet0/5/0/0.20`	Assigns the matching VLAN ID and Ethertype to the interface.

	Command or Action	Purpose
Step 6	**pbb core** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# pbb core`	Configures the bridge domain as PBB core and enters the PBB core configuration submode. This command also creates an internal port known as Customer bridge port (CBP). All the interfaces (bridge ports) under this bridge domain are treated as the provider network ports (PNP).
Step 7	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pbb-core)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pbb-core)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Backbone VLAN Tag under the PBB Core Bridge Domain

Perform this task to configure the backbone VLAN tag under the PBB core bridge domain.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *group-name*
4. **bridge-domain** *domain-name*
5. **interface** *type interface-path-id.subinterface*
6. **interface** *type interface-path-id.subinterface*
7. **pbb core**
8. **rewrite ingress tag push dot1ad** *vlan-id* **symmetric**
9. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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 pbb`	Enters configuration mode for the named bridge group. This command creates a new bridge group or modifies the existing bridge group if it already exists. A bridge group organizes bridge domains.
Step 4	**bridge-domain** *domain-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg)#bridge-domain pbb-core`	Enters configuration mode for the named bridge domain. This command creates a new bridge domain or modifies the existing bridge domain if it already exists.
Step 5	**interface** type interface-path-id.subinterface **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#interface GigabitEthernet0/5/0/0.20`	Assigns the matching VLAN ID and Ethertype to the interface.
Step 6	**interface** type interface-path-id.subinterface **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#interface GigabitEthernet0/5/0/1.15`	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. The interface now becomes an attachment circuit on this bridge domain.
Step 7	**pbb core** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# pbb core`	Configures the bridge domain as PBB core and enters the PBB core configuration submode. This command also creates an internal port known as Customer bridge port (CBP). All the interfaces (bridge ports) under this bridge domain are treated as the provider network ports (PNP).

	Command or Action	Purpose
Step 8	**rewrite ingress tag push dot1ad** *vlan-id* **symmetric** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pbb-core)# end`	Configures the backbone VLAN tag in the Mac-in-MAC frame and also, sets the tag rewriting policy. **Note** All PNPs in a Core bridge domain use the same backbone VLAN.
Step 9	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pbb-core)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pbb-core)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Backbone Source MAC Address

The backbone source MAC address (B-SA) is a unique address for a backbone network. Each Cisco ASR 9000 Series Router has one backbone source MAC address. If B-SA is not configured, then the largest MAC in the EEPROM is used as the PBB B-SA.

Note The backbone source MAC address configuration is optional. If you do not configure the backbone source MAC address, the Cisco ASR 9000 Series Routers allocate a default backbone source MAC address from the chassis backplane MAC pool.

Perform this task to configure the backbone source MAC address.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **pbb**
4. **backbone-source-mac** *mac-address*
5. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**l2vpn** **Example:** `RP/0/RSP0/CPU0:router(config)# l2vpn`	Enters L2VPN configuration mode.
Step 3	**pbb** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn)# pbb`	Enters PBB configuration mode.

	Command or Action	Purpose
Step 4	**backbone-source-address** *mac-address* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-pbb)# backbone-source-address 0045.1200.04`	Configures the backbone source MAC address.
Step 5	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-pbb)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-pbb)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Unknown Unicast Backbone MAC under PBB Edge Bridge Domain

Perform this task to configure the unknown unicast backbone MAC under the PBB edge bridge domain.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *group-name*
4. **bridge-domain** *domain-name*
5. **interface** *type interface-path-id.subinterface*
6. **pbb edge i-sid** service-id **core-bridge** *core-bridge-name*
7. **unknown-unicast-bmac** *mac-address*
8. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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 pbb`	Enters configuration mode for the named bridge group. This command creates a new bridge group or modifies the existing bridge group if it already exists. A bridge group organizes bridge domains.
Step 4	**bridge-domain** *domain-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg)#bridge-domain pbb-edge`	Enters configuration mode for the named bridge domain. This command creates a new bridge domain or modifies the existing bridge domain if it already exists.
Step 5	**interface** type interface-path-id.subinterface **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#interface GigabitEthernet0/5/0/0.20`	Assigns the matching VLAN ID and Ethertype to the interface.

	Command or Action	Purpose
Step 6	**pbb edge i-sid** *service-id* **core-bridge** *core-bridge-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# pbb edge i-sid 1000 core-bridge pbb-core`	Configures the bridge domain as PBB edge with the service identifier and the assigned core bridge domain and enters the PBB edge configuration submode. This command also creates the Virtual instance port (VIP) that associates the PBB Edge bridge domain to the specified Core bridge domain. All the interfaces (bridge ports) under this bridge domain are treated as the customer network ports (CNP).
Step 7	**unknown-unicast-bmac** *mac-address* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pbb-edge)# unknown-unicast-bmac 1.1.1`	Configures unknown unicast backbone MAC address. **Note** On Trident line cards, once you configure the unknown unicast BMAC, the BMAC is used to forward customer traffic with multicast, broadcast and unknown unicast destination MAC address.
Step 8	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pbb-edge)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pbb-edge)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Static MAC addresses under PBB Edge Bridge Domain

Perform this task to configure the static MAC addresses under the PBB edge bridge domain.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *group-name*
4. **bridge-domain** *domain-name*
5. **interface** *type interface-path-id.subinterface*
6. **interface** *type interface-path-id.subinterface*
7. **pbb edge i-sid** service-id **core-bridge** *core-bridge-name*
8. **static-mac-address** *cda-mac-address* **bmac** *bda-mac-address*
9. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters 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 pbb`	Enters configuration mode for the named bridge group. This command creates a new bridge group or modifies the existing bridge group if it already exists. A bridge group organizes bridge domains.
Step 4	**bridge-domain** *domain-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg)#bridge-domain pbb-edge`	Enters configuration mode for the named bridge domain. This command creates a new bridge domain or modifies the existing bridge domain if it already exists.
Step 5	**interface** type interface-path-id.subinterface **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)#interface GigabitEthernet0/5/0/0.20`	Assigns the matching VLAN ID and Ethertype to the interface.

	Command or Action	Purpose
Step 6	**interface** type interface-path-id.subinterface **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-ac)#interface GigabitEthernet0/5/0/1.15`	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. The interface now becomes an attachment circuit on this bridge domain.
Step 7	**pbb edge i-sid** *service-id* **core-bridge** *core-bridge-name* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd)# pbb edge i-sid 1000 core-bridge pbb-core`	Configures the bridge domain as PBB edge with the service identifier and the assigned core bridge domain and enters the PBB edge configuration submode. This command also creates the Virtual instance port (VIP) that associates the PBB Edge bridge domain to the specified Core bridge domain. All the interfaces (bridge ports) under this bridge domain are treated as the customer network ports (CNP).
Step 8	**static-mac-address** cda-*mac-address* **bmac** *b*da-*mac-address* **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pbb-edge)#static-mac-address 0033.3333.3333 bmac 0044.4444.4444`	Configures the static CMAC to BMAC mapping under the PBB Edge submode.
Step 9	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pbb-edge)# end` or `RP/0/RSP0/CPU0:router(config-l2vpn-bg-bd-pbb-edge)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuration Examples for Implementing 802.1ah Provider Backbone Bridge

This section provides these configuration examples:

Configuring Ethernet Flow Points: Example

This example shows how to configure Ethernet flow points:

```
config
interface GigabitEthernet0/0/0/10.100 l2transport
 encapsulation dot1q 100
or
 encapsulation dot1ad 100
or
 encapsulation dot1ad 100 dot1q 101
```

Configuring PBB Edge Bridge Domain and Service Instance ID: Example

This example shows how to configure the PBB edge bridge domain:

```
config
l2vpn
  bridge group PBB
    bridge-domain PBB-EDGE
    interface GigabitEthernet0/0/0/38.100
    !
    interface GigabitEthernet0/2/0/30.150
    !
    pbb edge i-sid 1000 core-bridge PBB-CORE
    !
 !
!
```

Configuring PBB Core Bridge Domain: Example

This example shows how to configure the PBB core bridge domain:

```
config
l2vpn
  bridge group PBB
    bridge-domain PBB-CORE
    interface G0/5/0/10.100
    !
    interface G0/2/0/20.200
    !
      pbb core
    !
  !
!
```

Configuring Backbone VLAN Tag: Example

This example shows how to configure the backbone VLAN tag:

```
config
l2vpn
  bridge group PBB
    bridge-domain PBB-CORE
    interface G0/5/0/10.100
    !
    interface G0/2/0/20.200
    !
      pbb core
        rewrite ingress tag push dot1ad 100 symmetric
    !
  !
!
```

Configuring Backbone Source MAC Address: Example

This example shows how to configure the backbone source MAC address:

```
config
l2vpn
  pbb
    backbone-source-mac 0045.1200.04
  !
!
```

Configuring Static Mapping and Unknown Unicast MAC Address under the PBB Edge Bridge Domain

This example shows how to configure static mapping and unknown unicast MAC address under the PBB edge bridge domain:

```
config
l2vpn
 bridge group PBB
   bridge-domain PBB-EDGE
   interface GigabitEthernet0/0/0/38.100
   !
   interface GigabitEthernet0/2/0/30.150
   !
   pbb edge i-sid 1000 core-bridge PBB-CORE
     static-mac-address 0033.3333.3333 bmac 0044.4444.4444
     unknown-unicast-bmac 0123.8888.8888
   !
 !
!
```

Additional References

These sections provide references related to implementing 802.1ah on Cisco ASR 9000 Series Routers.

Related Documents

Related Topic	Document Title
802.1ah commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples	*Provider Backbone Bridge Commands* module in *Cisco ASR 9000 Series Aggregation Services Router L2VPN and Ethernet Services Command Reference*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
—	To locate and download MIBs using Cisco IOS XR software, use the Cisco MIB Locator found at this URL and choose a platform under the Cisco Access Products menu: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport

Implementing Multiple Spanning Tree Protocol

This module provides conceptual and configuration information for Multiple Spanning Tree Protocol on Cisco ASR 9000 Series Routers. Multiple Spanning Tree Protocol (MSTP) is a spanning-tree protocol used to prevent loops in bridge configurations. Unlike other types of STPs, MSTP can block ports selectively by VLAN.

Feature History for Implementing Multiple Spanning Tree Protocol

Release	Modification
Release 3.7.3	This feature was introduced on Cisco ASR 9000 Series Routers.
Release 3.9.1	Support for MSTP over Bundles feature was added.
Release 4.0.1	Support for PVST+ and PVSTAG features was added.
Release 4.1.0	Support for MSTAG Edge Mode feature was added.

Contents

Prerequisites for Implementing Multiple Spanning Tree Protocol

This prerequisite applies to implementing MSTP:

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.

Information About Implementing Multiple Spanning Tree Protocol

To implement Ethernet services access lists, you must understand these concepts:

- Spanning Tree Protocol Overview
- Multiple Spanning Tree Protocol Overview
- MSTP Supported Features
- Restrictions for configuring MSTP
- Access Gateway
- Multiple VLAN Registration Protocol

Spanning Tree Protocol Overview

Ethernet is no longer just a link-layer technology used to interconnect network vehicles and hosts. Its low cost and wide spectrum of bandwidth capabilities coupled with a simple *plug and play* provisioning philosophy have transformed Ethernet into a legitimate technique for building networks, particularly in the access and aggregation regions of service provider networks.

Ethernet networks lacking a TTL field in the Layer 2 (L2) header and, encouraging or requiring multicast traffic network-wide, are susceptible to broadcast storms if loops are introduced. However, loops are a desirable property as they provide redundant paths. Spanning tree protocols (STP) are used to provide a loop free topology within Ethernet networks, allowing redundancy within the network to deal with link failures.

There are many variants of STP; however, they work on the same basic principle. Within a network that may contain loops, a sufficient number of interfaces are disabled by STP so as to ensure that there is a loop-free spanning tree, that is, there is exactly one path between any two devices in the network. If there is a fault in the network that affects one of the active links, the protocol recalculates the spanning tree so as to ensure that all devices continue to be reachable. STP is transparent to end stations which cannot detect whether they are connected to a single LAN segment or to a switched LAN containing multiple segments and using STP to ensure there are no loops.

STP Protocol Operation

All variants of STP operate in a similar fashion: STP frames (known as bridge protocol data units (BPDUs)) are exchanged at regular intervals over Layer 2 LAN segments, between network devices participating in STP. Such network devices do not forward these frames, but use the information to construct a loop free spanning tree.

The spanning tree is constructed by first selecting a device which is the *root* of the spanning tree (known as the *root bridge*), and then by determining a loop free path from the root bridge to every other device in the network. Redundant paths are disabled by setting the appropriate ports into a blocked state, where STP frames can still be exchanged but data traffic is never forwarded. If a network segment fails and a redundant path exists, the STP protocol recalculates the spanning tree topology and activates the redundant path, by unblocking the appropriate ports.

The selection of the root bridge within an STP network is determined by the configured priority and the embedded bridge ID of each device. The device with the lowest priority, or with equal lowest priority but the lowest bridge ID, is selected as the root bridge.

The selection of the active path among a set of redundant paths is determined primarily by the port path cost. The port path cost represents the cost of transiting between that port and the root bridge - the further the port is from the root bridge, the higher the cost. The cost is incremented for each link in the path, by an amount that is (by default) dependent on the media speed. Where two paths from a given LAN segment have an equal cost, the selection is further determined by the priority and bridge ID of the attached devices, and in the case of two attachments to the same device, by the configured port priority and port ID of the attached ports.

Once the active paths have been selected, any ports that do not form part of the active topology are moved to the blocking state.

Topology Changes

Network devices in a switched LAN perform MAC learning; that is, they use received data traffic to associate unicast MAC addresses with the interface out of which frames destined for that MAC address should be sent. If STP is used, then a recalculation of the spanning tree (for example, following a failure in the network) can invalidate this learned information. The protocol therefore includes a mechanism to notify topology changes around the network, so that the stale information can be removed (flushed) and new information can be learned based on the new topology.

A *Topology Change* notification is sent whenever STP moves a port from the blocking state to the forwarding state. When it is received, the receiving device flushes the MAC learning entries for all ports that are not blocked other than the one where the notification was received, and also sends its own topology change notification out of those ports. In this way, it is guaranteed that stale information is removed from all the devices in the network.

Variants of STP

There are many variants of the Spanning Tree Protocol:

- Legacy STP (STP)—The original STP protocol was defined in IEEE 802.1D-1998. This creates a single spanning tree which is used for all VLANs and most of the convergence is timer-based.
- Rapid STP (RSTP)—This is an enhancement defined in IEEE 802.1D-2004 to provide more event-based, and hence faster, convergence. However, it still creates a single spanning tree for all VLANs.

- Multiple STP (MSTP)—A further enhancement was defined in IEEE 802.1Q-2005. This allows multiple spanning trees to be created over the same physical topology. By assigning different VLANs to the different spanning trees, data traffic can be load-balanced over different physical links. The number of different spanning trees that can be created is restricted to a much smaller number than the number of possible VLANs; however, multiple VLANs can be assigned to the same spanning tree. The BPDUs used to exchange MSTP information are always sent untagged; the VLAN and spanning tree instance data is encoded inside the BPDU.
- Per-Vlan STP (PVST)—This is an alternative mechanism for creating multiple spanning trees; it was developed by Cisco before the standardization of MSTP. Using PVST, a separate spanning tree is created for each VLAN. There are two variants: PVST+ (based on legacy STP), and PVRST (based on RSTP). At a packet level, the separation of the spanning trees is achieved by sending standard STP or RSTP BPDUs, tagged with the appropriate VLAN tag.
- REP (Cisco-proprietary ring-redundancy protocol)— This is a Cisco-proprietary protocol for providing resiliency in rings. It is included for completeness, as it provides MSTP compatibility mode, using which, it interoperates with an MSTP peer.

Multiple Spanning Tree Protocol Overview

The Multiple Spanning Tree Protocol (MSTP) is an STP variant that allows multiple and independent spanning trees to be created over the same physical network. The parameters for each spanning tree can be configured separately, so as to cause a different network devices to be selected as the root bridge or different paths to be selected to form the loop-free topology. Consequently, a given physical interface can be blocked for some of the spanning trees and unblocked for others.

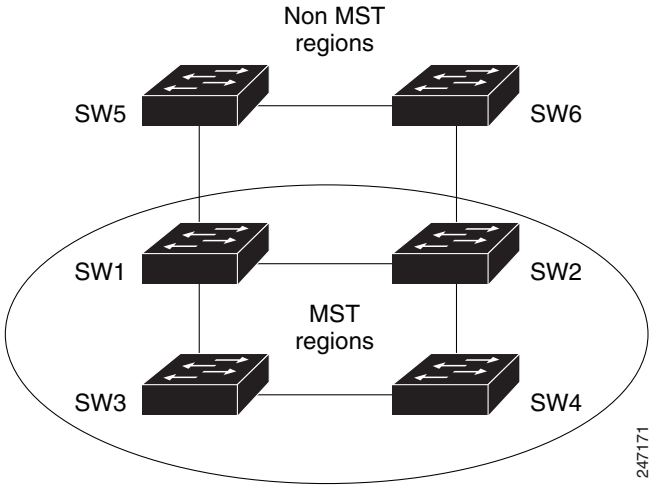
Having set up multiple spanning trees, the set of VLANs in use can be partitioned among them; for example, VLANs 1 - 100 can be assigned to spanning tree 1, VLANs 101 - 200 can be assigned to spanning tree 2, VLANs 201 - 300 can be assigned to spanning tree 3, and so on. Since each spanning tree has a different active topology with different active links, this has the effect of dividing the data traffic among the available redundant links based on the VLAN - a form of load balancing.

MSTP Regions

Along with supporting multiple spanning trees, MSTP also introduces the concept of regions. A region is a group of devices under the same administrative control and have similar configuration. In particular, the configuration for the region name, revision, and the mapping of VLANs to spanning tree instances must be identical on all the network devices in the region. A digest of this information is included in the BPDUs sent by each device, so as to allow other devices to verify whether they are in the same region.

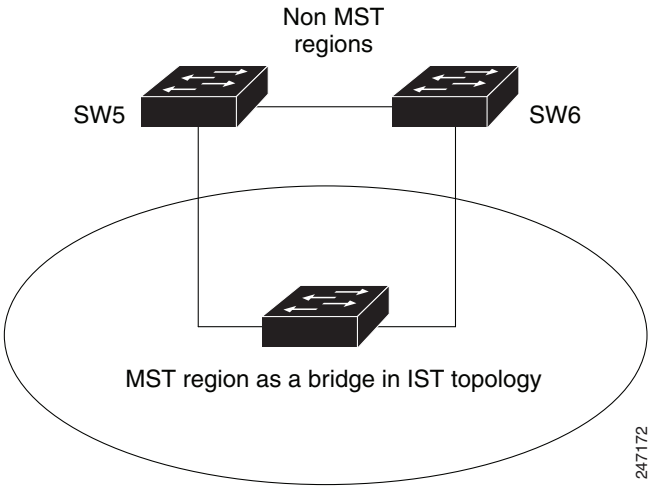
Figure 27 shows the operation of MST regions when bridges running MSTP are connected to bridges running legacy STP or RSTP. In this example, switches SW1, SW2, SW3, SW4 support MSTP, while switches SW5 and SW6 do not.

Figure 27 MST Interaction with Non-MST Regions



To handle this situation, an Internal Spanning Tree (IST) is used. This is always spanning tree instance 0 (zero). When communicating with non-MSTP-aware devices, the entire MSTP region is represented as a single switch. The logical IST topology in this case is shown in Figure 28.

Figure 28 Logical Topology in MST Region Interacting with Non-MST Bridges



The same mechanism is used when communicating with MSTP devices in a different region. For example, SW5 in Figure 28 could represent a number of MSTP devices, all in a different region compared to SW1, SW2, SW3 and SW4.

MSTP Port Fast

MSTP includes a *Port Fast* feature for handling ports at the edge of the switched Ethernet network. For devices that only have one link to the switched network (typically host devices), there is no need to run MSTP, as there is only one available path. Furthermore, it is undesirable to trigger topology changes (and resultant MAC flushes) when the single link fails or is restored, as there is no alternative path.

By default, MSTP monitors ports where no BPDUs are received, and after a timeout, places them into *edge mode* whereby they do not participate in MSTP. However, this process can be speeded up (and convergence of the whole network thereby improved) by explicitly configuring edge ports as port fast.

Note Port Fast is implemented as a Cisco-proprietary extension in Cisco implementations of legacy STP. However, it is encompassed in the standards for RSTP and MSTP, where it is known as Edge Port.

MSTP Root Guard

In networks with shared administrative control, it may be desirable for the network administrator to enforce aspects of the network topology and in particular, the location of the root bridge. By default, any device can become the root bridge for a spanning tree, if it has a lower priority or bridge ID. However, a more optimal forwarding topology can be achieved by placing the root bridge at a specific location in the centre of the network.

Note The administrator can set the root bridge priority to 0 in an effort to secure the root bridge position; however, this is no guarantee against another bridge which also has a priority of 0 and has a lower bridge ID.

The root guard feature provides a mechanism that allows the administrator to enforce the location of the root bridge. When root guard is configured on an interface, it prevents that interface from becoming a root port (that is, a port via which the root can be reached). If superior information is received via BPDUs on the interface that would normally cause it to become a root port, it instead becomes a backup or alternate port. In this case, it is placed in the blocking state and no data traffic is forwarded.

The root bridge itself has no root ports. Thus, by configuring root guard on every interface on a device, the administrator forces the device to become the root, and interfaces receiving conflicting information are blocked.

Note Root Guard is implemented as a Cisco-proprietary extension in Cisco implementations of legacy STP and RSTP. However, it is encompassed in the standard for MSTP, where it is known as Restricted Role.

MSTP Topology Change Guard

In certain situations, it may be desirable to prevent topology changes originating at or received at a given port from being propagated to the rest of the network. This may be the case, for example, when the network is not under a single administrative control and it is desirable to prevent devices external to the core of the network from causing MAC address flushing in the core. This behavior can be enabled by configuring Topology Change Guard on the port.

Note Topology Change Guard is known as *Restricted TCN* in the MSTP standard.

MSTP Supported Features

Cisco ASR 9000 Series Routers support MSTP, as defined in IEEE 802.1Q-2005, on physical Ethernet interfaces and Ethernet Bundle interfaces. Note that this includes the Port Fast, Backbone Fast, Uplink Fast and Root Guard features found in Cisco implementations of legacy STP, RSTP and PVST, as these are encompassed by the standard MSTP protocol. Cisco ASR 9000 Series Routers can operate in either standard 802.1Q mode, or in Provide Edge (802.1ad) mode. In provider edge mode, a different MAC address is used for BPDUs, and any BPDUs received with the 802.1Q MAC address are forwarded transparently.

In addition, these additional Cisco features are supported:

- BPDU Guard—This Cisco feature protects against misconfiguration of edge ports.
- Flush Containment—This Cisco feature helps prevent unnecessary MAC flushes that would otherwise occur following a topology change.
- Bringup Delay—This Cisco feature prevents an interface from being added to the active topology before it is ready to forward traffic.

Note Interoperation with RSTP is supported, as described in the 802.1Q standard; however, interoperation with legacy STP is not supported.

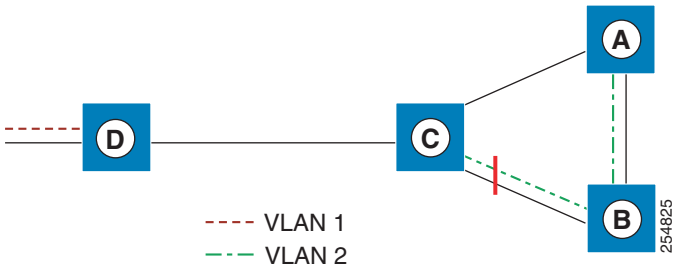
BPDU Guard

BPDU Guard is a Cisco feature that protects against misconfiguration of edge ports. It is an enhancement to the MSTP port fast feature. When port fast is configured on an interface, MSTP considers that interface to be an edge port and removes it from consideration when calculating the spanning tree. When BPDU Guard is configured, MSTP additionally shuts down the interface using error-disable if an MSTP BPDU is received.

Flush Containment

Flush containment is a Cisco feature that helps prevent unnecessary MAC flushes due to unrelated topology changes in other areas of a network. This is best illustrated by example. Figure 29 shows a network containing four devices. Two VLANs are in use: VLAN 1 is only used on device D, while VLAN 2 spans devices A, B and C. The two VLANs are in the same spanning tree instance, but do not share any links.

Figure 29 Flush Containment



If the link AB goes down, then in normal operation, as C brings up its blocked port, it sends out a topology change notification on all other interfaces, including towards D. This causes a MAC flush to occur for VLAN 1, even though the topology change which has taken place only affects VLAN 2.

Flush containment helps deal with this problem by preventing topology change notifications from being sent on interfaces on which no VLANs are configured for the MSTI in question. In the example network this would mean no topology change notifications would be sent from C to D, and the MAC flushes which take place would be confined to the right hand side of the network.

Note Flush containment is enabled by default, but can be disabled by configuration, thus restoring the behavior described in the IEEE 802.1Q standard.

Bringup Delay

Bringup delay is a Cisco feature that stops MSTP from considering an interface when calculating the spanning tree, if the interface is not yet ready to forward traffic. This is useful when a line card first boots up, as the system may declare that the interfaces on that card are *Up* before the dataplane is fully ready to forward traffic. According to the standard, MSTP considers the interfaces as soon as they are declared *Up*, and this may cause it to move other interfaces into the blocking state if the new interfaces are selected instead.

Bringup delay solves this problem by adding a configurable delay period which occurs as interfaces that are configured with MSTP first come into existence. Until this delay period ends, the interfaces remain in blocking state, and are not considered when calculating the spanning tree.

Bringup delay only takes place when interfaces which are already configured with MSTP are created, for example, on a card reload. No delay takes place if an interface which already exists is later configured with MSTP.

Restrictions for configuring MSTP

These restrictions apply when using MSTP:

- MSTP must only be enabled on interfaces where the interface itself (if it is in L2 mode) or all of the subinterfaces have a simple encapsulation configured. These encapsulation matching criteria are considered simple:
  - Single-tagged 802.1Q frames
  - Double-tagged Q-in-Q frames (only the outermost tag is examined)
  - 802.1ad frames (if MSTP is operating in Provider Bridge mode)
  - Ranges or lists of tags (any of the above)

Note Subinterfaces with a **default** and **untagged** encapsulation are not supported.

- If an L2 interface or subinterface is configured with an encapsulation that matches multiple VLANs, then all of those VLANs must be mapped to the same spanning tree instance. There is therefore a single spanning tree instance associated with each L2 interface or subinterface.
- All the interfaces or subinterfaces in a given bridge domain must be associated with the same spanning tree instance.
- Multiple subinterfaces on the same interface must not be associated with the same spanning tree instance, unless those subinterfaces are in the same split horizon group. In other words, hair-pinning is not possible.

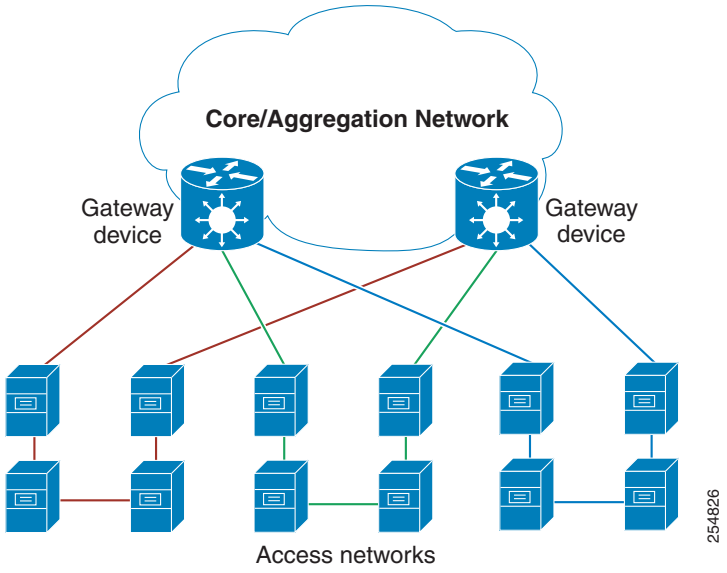
- Across the network, L2 interfaces or subinterfaces must be configured on all redundant paths for all the VLANs mapped to each spanning tree instance. This is to avoid inadvertent loss of connectivity due to STP blocking of a port.

Caution A subinterface with a default or untagged encapsulation will lead to an MSTP state machine failure.

Access Gateway

One common deployment scenario for Cisco ASR 9000 Series Routers is as an nPE gateway device situated between a network of uPE access devices and a core or aggregation network. Each gateway device may provide connectivity for many access networks, as shown in Figure 30. The access networks (typically rings) have redundant links to the core or aggregation network, and therefore must use some variant of STP or a similar protocol to ensure the network remains loopfree.

Figure 30 Core or Aggregation Network



It is possible for the gateway devices to also participate in the STP protocol. However, since each gateway device may be connected to many access networks, this would result in one of two solutions:

- A single topology is maintained covering all of the access networks. This is undesirable as it means topology changes in one access network could impact all the other access networks.
- The gateway devices runs multiple instances of the STP protocol, one for each access network. This means a separate protocol database and separate protocol state machines are maintained for each access network, which is undesirable due to the memory and CPU resource that would be required on the gateway device.

It can be seen that both of these options have significant disadvantages.

Another alternative is for the gateway devices to tunnel protocol BPDUs between the *legs* of each access network, but not to participate in the protocol themselves. While this results in correct loopfree topologies, it also has significant downsides:

- Since there is no direct connection between the *legs* of the access ring, a failure in one of the *leg* links is not immediately detected by the access device connected to the other *leg*. Therefore, recovery from the failure must wait for protocol timeouts, which leads to a traffic loss of at least six seconds.
- As the gateway devices do not participate in the protocol, they are not aware of any topology changes in the access network. The aggregation network may therefore direct traffic destined for the access network over the wrong *leg*, following a topology change. This can lead to traffic loss on the order of the MAC learning timeout (5 minutes by default).

Access gateway is a Cisco feature intended to address this deployment scenario, without incurring the disadvantages of the solutions described above.

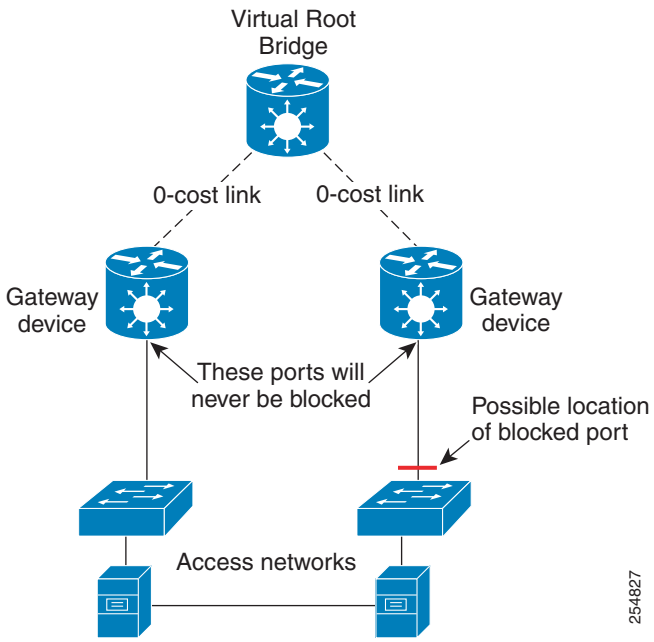
Overview of Access Gateway

Access gateway is based on two assumptions:

- Both gateway devices provide connectivity to the core or aggregation network at all times. Generally, resiliency mechanisms used within the core or aggregation network are sufficient to ensure this is the case. In many deployments, VPLS is used in the core or aggregation network to provide this resiliency.
- The desired root of all of the spanning trees for each access network is one of the gateway devices. This will be the case if (as is typical) the majority of the traffic is between an access device and the core or aggregation network, and there is little if any traffic between the access devices.

With these assumptions, an STP topology can be envisaged where for every spanning tree, there is a virtual root bridge behind (that is, on the core side of) the gateway devices, and both gateway devices have a zero cost path to the virtual root bridge. In this case, the ports that connect the gateway devices to the access network would never be blocked by the spanning tree protocol, but would always be in the forwarding state. This is illustrated inFigure 31.

Figure 31 Access Networks



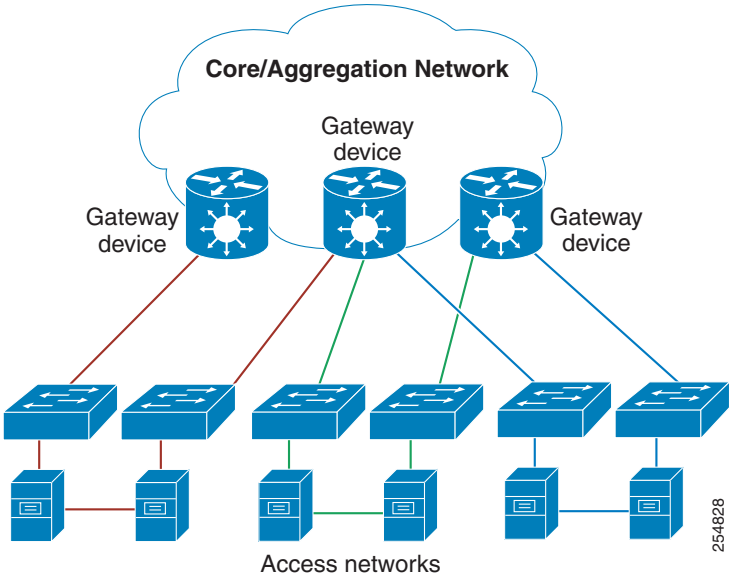
With this topology, it can be observed that the BPDUs sent by the gateway devices are constant: since the root bridge never changes (as we assume the aggregation or core network always provides connectivity) and the ports are always forwarding, the information sent in the BPDUs never changes.

Access gateway makes use of this by removing the need to run the full STP protocol and associated state machines on the gateway devices, and instead just sends statically configured BPDUs towards the access network. The BPDUs are configured so as to mimic the behavior above, so that they contain the same information that would be sent if the full protocol was running. To the access devices, it appears that the gateway devices are fully participating in the protocol; however, since in fact the gateway devices are just sending static BPDUs, very little memory or CPU resource is needed on the gateway devices, and many access networks can be supported simultaneously.

For the most part, the gateway devices can ignore any BPDUs received from the access network; however, one exception is when the access network signals a topology change. The gateway devices can act on this appropriately, for example by triggering an LDP MAC withdrawal in the case where the core or aggregation network uses VPLS.

In many cases, it is not necessary to have direct connectivity between the gateway devices; since the gateway devices statically send configured BPDUs over the access links, they can each be configured independently (so long as the configuration on each is consistent). This also means that different access networks can use different pairs of gateway devices, as shown in Figure 32.

Figure 32 Access Networks



Note Although Figure 32 shows access rings, in general there are no restrictions on the access network topology or the number or location of links to the gateway devices.

Access gateway ensures loop-free connectivity in the event of these failure cases:

- Failure of a link in the access network.
- Failure of a link between the access network and the gateway device.
- Failure of an access device.
- Failure of a gateway device.

Topology Change Propagation

There is one case where the two gateway devices need to exchange BPDUs between each other, and this is to handle topology changes in the access network. If a failure in the access network results in a topology change that causes a previously blocked port to move to forwarding, the access device sends a topology change notification out on that port, so as to notify the rest of the network about the change and trigger the necessary MAC learning flushes. Typically, the topology change notification is sent towards the root bridge, in the case of access gateway, that means it is sent to one of the gateway devices.

As described above, this causes the gateway device itself to take any necessary action; however, if the failure caused the access network to become partitioned, it may also be necessary to propagate the topology change notification to the rest of the access network, that is, the portion connected to the other gateway device. This can be achieved by ensuring there is connectivity between the gateway devices, so that each gateway device can propagate any topology change notifications it receives from the access network to the other device. When a gateway device receives a BPDU from the other gateway device that indicates a topology change, it signals this in the static BPDUs (that it is sending towards the access network).

Topology Change Propagation is only necessary when these two conditions are met:

- The access network contains three or more access devices. If there are fewer than three devices, then any possible failure must be detected by all the devices.
- The access devices send traffic to each other, and not just to or from the core or aggregation network. If all the traffic is to or from the core or aggregation network, then all the access devices must either already be sending traffic in the right direction, or will learn about the topology change from the access device that originates it.

Preempt Delay

One of the assumptions underpinning access gateway is that the gateway devices are always available to provide connectivity to the core or aggregation network. However, there is one situation where this assumption may not hold, which is at bringup time. At bringup, it may be the case that the access facing interface is available before all of the necessary signaling and convergence has completed that means traffic can successfully be forwarded into the core or aggregation network. Since access gateway starts sending BPDUs as soon as the interface comes up, this could result in the access devices sending traffic to the gateway device before it is ready to receive it. To avoid this problem, the preempt delay feature is used.

The preempt delay feature causes access gateway to send out inferior BPDUs for some period of time after the interface comes up, before reverting to the normal values. These inferior BPDUs can be configured such that the access network directs all traffic to the other gateway device, unless the other gateway device is also down. If the other gateway device is unavailable, it is desirable for the traffic to be sent to this device, even if it is only partially available, rather than being dropped completely. For this reason, inferior BPDUs are sent during the preempt delay time, rather than sending no BPDUs at all.

Supported Access Gateway Protocols

Access Gateway is supported on Cisco ASR 9000 Series Routers when the following protocols are used in the access network.

Table 3 Protocols

Access Network Protocol	Access Gateway Variant
MSTP	MST Access Gateway (MSTAG)
REP	REP Access gateway (REPAG)[1]
PVST+	PVST+ Access Gateway (PVSTAG)[2]
PVRST	PVRST Access Gateway (PVRSTAG)[3]

1. REP Access Gateway is supported when the access device interfaces that connect to the gateway devices are configured with REP MSTP Compatibility mode.
2. Topology Change Propagation is not supported for PVSTAG.
3. Topology Change Propagation is not supported for PVRSTAG.

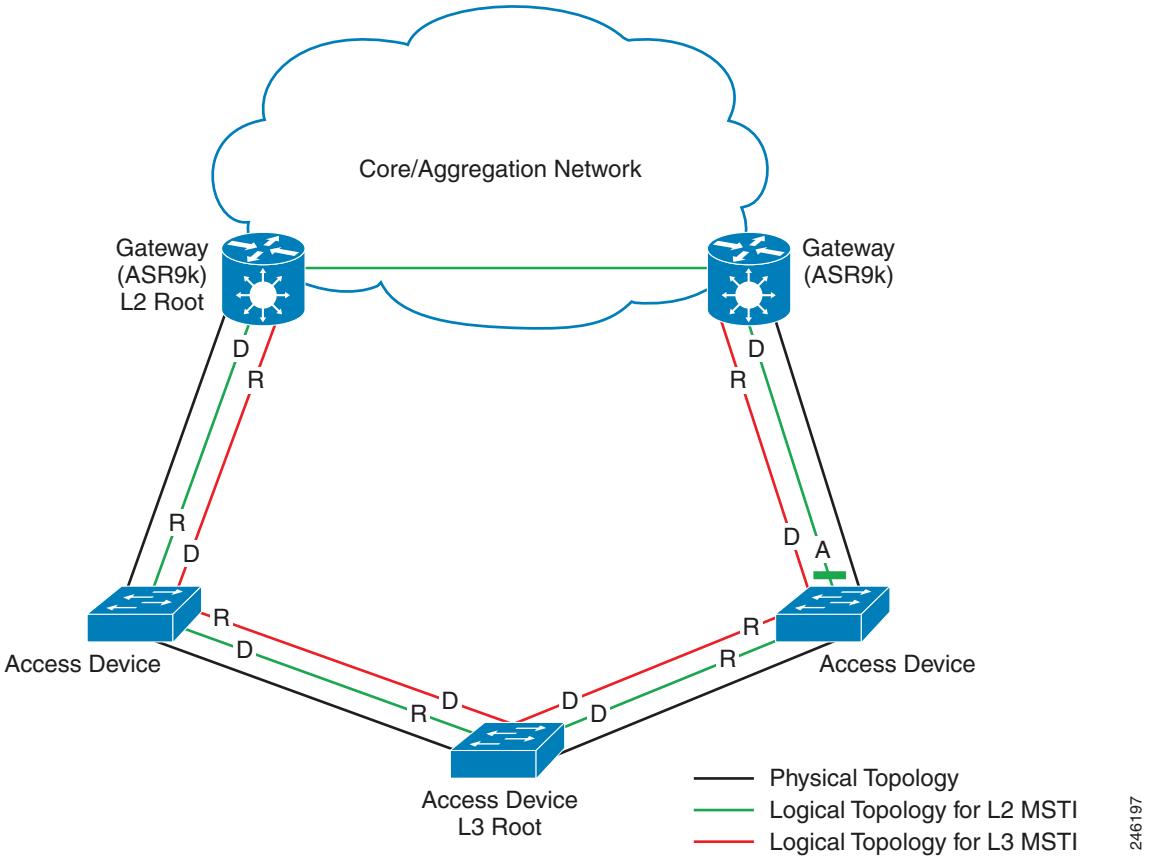
MSTAG Edge Mode

An access gateway is used in a Layer 2 (L2) environment to ensure that for each Multiple Spanning Tree Instance (MSTI), each access device has one path to the core or aggregation network. The core or aggregation network provides L2 (Ethernet) connectivity between two gateway devices. Therefore, when there are no failures, there must be at least one blocked port in the access network for each MSTI. In the case of an access ring, there should be one blocked port in the access ring. For each MSTI – this is typically one of the uplink ports that connects to one of the gateway devices. This is achieved by configuring MSTAG in such a way that the gateway devices appear to have the best path to the best possible Multiple Spanning Tree Protocol (MSTP) root node. Thus, the access devices always use the gateway devices to reach the root, and the ports on the gateway devices are always in the designated forwarding state.

In a mixed Layer 2-Layer 3 environment, the L2 access network is used to provide a Layer 2 service on certain VLANs and a Layer 3 (L3) service on other VLANs. In the access network, a different MSTI is used for the L2 service and the L3 service. For the L2 VLANs, the core or aggregation network provides L2 connectivity between the gateway devices. However, for the L3 service, the gateway devices terminate the L2 network and perform L3 routing. Typically, an L3 redundancy mechanism such as HSRP or VRRP is used to allow the end hosts to route to the correct gateway.

In this scenario, the use of MSTAG alone does not achieve the desired behavior for the L3 MSTI. This is because it results in one of the ports in the access network being blocked, even though there is actually no loop. (This, in turn, is because there is no L2 connectivity between the gateway devices for the L3 VLANs.) In fact, because the gateway devices terminate the L2 network for the L3 VLANs, the desirable behavior is for the MSTP root to be located in the access network, and for the gateway devices to appear as leaf nodes with a single connection. This can be achieved by reversing the MSTAG configuration; that is, setting the gateway devices to advertise the worst possible path to the worst possible root. This forces the access devices to elect one of the access devices as the root, and therefore, no ports are blocked. In this case, the ports on the gateway devices are always in root forwarding state. The MSTAG Edge mode feature enables this scenario by changing the role advertised by the gateway devices from designated to root. Figure 33 illustrates this scenario.

Figure 33 MSTAG Edge Mode scenario



D - Designated port (forwarding)
R - Root port (forwarding)
A - Alternate port (blocked)

For normal MSTAG, and for the L2 MSTIs, topology change notifications are propagated from one gateway device to the other, and re-advertised into the access network. However, for the L3 MSTI, this is not desirable. As there is no block for the L3 MSTI in the access network, the topology change notification could loop forever. To avoid that situation, MSTAG Edge mode completely disables handling of topology change notifications in the gateway devices.

Multiple VLAN Registration Protocol

The Multiple VLAN Registration Protocol is defined in IEEE 802.1ak and is used in MSTP based networks to optimize the propagation of multicast and broadcast frames.

By default, multicast and broadcast frames are propagated to every point in the network, according to the spanning tree, and hence to every edge (host) device that is attached to the network. However, for a given VLAN, it may be the case that only certain hosts are interested in receiving the traffic for that VLAN. Furthermore, it may be the case that a given network device, or even an entire segment of the network, has no attached hosts that are interested in receiving traffic for that VLAN. In this case, an optimization is possible by avoiding propagating traffic for that VLAN to those devices that have no stake in it. MVRP provides the necessary protocol signaling that allows each host and device to indicate to its attached peers which VLANs it is interested in.

MVRP-enabled devices can operate in two modes:

- Static mode—In this mode, the device initiates MVRP messages declaring interest in a statically configured set of VLANs. Note that the protocol is still dynamic with respect to the MSTP topology; it is the set of VLANs that is static.
- Dynamic mode—In this mode, the device processes MVRP messages received on different ports, and aggregates them dynamically to determine the set of VLANs it is interested in. It sends MVRP messages declaring interest in this set. In dynamic mode, the device also uses the received MVRP messages to prune the traffic sent out of each port so that traffic is only sent for the VLANs that the attached device has indicated it is interested in.

Cisco ASR 9000 Series Routers support operating in static mode. This is known as MVRP-lite.

How to Implement Multiple Spanning Tree Protocol

This section contains these procedures:

- Configuring MSTP
- Configuring MSTAG or REPAG
- Configuring PVSTAG or PVRSTAG
- Configuring MVRP-lite

Configuring MSTP

This section describes the procedure for configuring MSTP:

- Enabling MSTP
- Configuring MSTP parameters
- Verifying MSTP

Note This section does not describe how to configure data switching. Refer to the *Implementing Multipoint Layer 2 Services* module for more information.

Enabling MSTP

By default, STP is disabled on all interfaces. MSTP should be explicitly enabled by configuration on each physical or Ethernet Bundle interface. When MSTP is configured on an interface, all the subinterfaces of that interface are automatically MSTP-enabled.

Configuring MSTP parameters

The MSTP Standard defines a number of configurable parameters. The global parameters are:

- Region Name and Revision
- Bringup Delay
- Forward Delay
- Max Age or Hops
- Transmit Hold Count
- Provider Bridge mode
- Flush Containment
- VLAN IDs (per spanning-tree instance)
- Bridge Priority (per spanning-tree instance)

The per-interface parameters are:

- External port path cost
- Hello Time
- Link Type

- Port Fast and BPDU Guard
- Root Guard and Topology Change Guard
- Port priority (per spanning-tree instance)
- Internal port path cost (per spanning-tree instance)

Per-interface configuration takes place in an interface submode within the MST configuration submode.

Note The configuration steps listed in the following sections show all of the configurable parameters. However, in general, most of these can be retained with the default value.

SUMMARY STEPS

1. **configure**
2. **spanning-tree mst** *protocol instance identifier*
3. **bringup delay for** *interval* {**minutes | seconds**}
4. **flush containment disable**
5. **name** *name*
6. **revision** *revision*-number
7. **forward-delay** *seconds*
8. **maximum {age** *seconds* | **hops** *hops*}
9. **transmit hold-count** *count*
10. **provider-bridge**
11. **instance** *id*
12. **priority** *priority*
13. **vlan-id** *vlan-range* [,*vlan-range*][,*vlan-range*][,*vlan-range*]
14. **interface {Bundle-Ether | GigabitEthernet | TenGigE | FastEthernet}** *instance*
15. **instance** *id* **port-priority** *priority*
16. **instance** *id* **cost** *cost*
17. **external-cost** *cost*
18. **link-type** {**point-to-point | multipoint}**
19. **hello-time** *seconds*
20. **portfast** [**bpdu-guard]**
21. **guard root**
22. **guard topology-change**
23. **end**
    or
    commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# config` `Thu Jun  4 07:50:02.660 PST` `RP/0/RSP0/CPU0:router(config)#`	Enters global configuration mode.
Step 2	**spanning-tree mst** *protocol instance identifier* **Example:** `RP/0/RSP0/CPU0:router(config)#` **spanning-tree mst a** `RP/0/RSP0/CPU0:router(config-mstp)#`	Enters the MSTP configuration submode.
Step 3	**bringup delay for** *interval* {**minutes** | **seconds**} Example: `RP/0/RSP0/CPU0:router(config-mstp)#` **bringup delay for 10 minutes**	Configures the time interval to delay bringup for.
Step 4	**flush containment disable** Example: `RP/0/RSP0/CPU0:router(config-mstp)#` **flush containment disable**	Disable flush containment. This command performs MAC flush on all instances regardless of the their state.
Step 5	**name** *name* **Example:** `RP/0/RSP0/CPU0:router(config-mstp)#` **name m1**	Sets the name of the MSTP region. The default value is the MAC address of the switch, formatted as a text string by means of the hexadecimal representation specified in IEEE Std 802.
Step 6	**revision** *revision*-number **Example:** `RP/0/RSP0/CPU0:router(config-mstp)#` **revision 10**	Sets the revision level of the MSTP region. Allowed values are from 0 through 65535.
Step 7	**forward-delay** *seconds* **Example:** `RP/0/RSP0/CPU0:router(config-mstp)#` **forward-delay 20**	Sets the forward-delay parameter for the bridge. Allowed values for bridge forward-delay time in seconds are from 4 through 30.
Step 8	**maximum {age** *seconds* | **hops** *hops*} **Example:** `RP/0/RSP0/CPU0:router(config-mstp)#` **max age 40** `RP/0/RSP0/CPU0:router(config-mstp)#` **max hops 30**	Sets the maximum age and maximum hops performance parameters for the bridge. Allowed values for maximum age time for the bridge in seconds are from 6 through 40. Allowed values for maximum number of hops for the bridge in seconds are from 6 through 40.

	Command or Action	Purpose
Step 9	**transmit hold-count** *count* **Example:** RP/0/RSP0/CPU0:router(config-mstp)# **transmit hold-count 8**	Sets the transmit hold count performance parameter. Allowed values are from 1 through 10.
Step 10	**provider-bridge** **Example:** RP/0/RSP0/CPU0:router(config-mstp)# **provider-bridge**	Places the current instance of the protocol in 802.1ad mode.
Step 11	**instance** *id* **Example:** RP/0/RSP0/CPU0:router(config-mstp)# **instance 101** RP/0/RSP0/CPU0:router(config-mstp-inst)#	Enters the MSTI configuration submode. Allowed values for the MSTI ID are from 0 through 4094.
Step 12	**priority** *priority* **Example:** RP/0/RSP0/CPU0:router(config-mstp-inst)# **priority 8192**	Sets the bridge priority for the current MSTI. Allowed values are from 0 through 61440 in multiples of 4096.
Step 13	**vlan-id** *vlan-range* [,*vlan-range*][,*vlan-range*][,*vlan-range*] **Example:** RP/0/RSP0/CPU0:router(config-mstp-inst)# **vlan-id 2-1005**	Associates a set of VLAN IDs with the current MSTI. List of VLAN ranges in the form a-b, c, d, e-f, g, and so on. **Note** Repeat steps 11 to 13 for each MSTI.
Step 14	**interface {Bundle-Ether | GigabitEthernet | TenGigE | FastEthernet}** *instance* **Example:** RP/0/RSP0/CPU0:router(config-mstp)# **interface FastEthernet 0/0/0/1** RP/0/RSP0/CPU0:router(config-mstp-if)#	Enters the MSTP interface configuration submode, and enables STP for the specified port. Forward interface in Rack/Slot/Instance/Port format.
Step 15	**instance** *id* **port-priority** *priority* **Example:** RP/0/RSP0/CPU0:router(config-mstp-if)# **instance 101 port-priority 160**	Sets the port priority performance parameter for the MSTI. Allowed values for the MSTI ID are from 0 through 4094. Allowed values for port priority are from 0 through 240 in multiples of 16.
Step 16	**instance** *id* **cost** *cost* **Example:** RP/0/RSP0/CPU0:router(config-mstp-if)# **instance 101 cost 10000**	Sets the internal path cost for a given instance on the current port. Allowed values for the MSTI ID are from 0 through 4094. Allowed values for port cost are from 1 through 200000000. **Note** Repeat steps 15 and 16 for each MSTI for each interface.

	Command or Action	Purpose
Step 17	**external-cost** *cost* **Example:** RP/0/RSP0/CPU0:router(config-mstp-if)# **external-cost 10000**	Sets the external path cost on the current port. Allowed values for port cost are from 1 through 200000000.
Step 18	**link-type** {**point-to-point** | **multipoint**} **Example:** RP/0/RSP0/CPU0:router(config-mstp-if)# **link-type point-to-point**	Sets the link type of the port to point-to-point or multipoint.
Step 19	**hello-time** *seconds* **Example:** RP/0/RSP0/CPU0:router(config-mstp-if)# **hello-time 1**	Sets the port hello time in seconds. Allowed values are 1 and 2.
Step 20	**portfast** [**bpdu-guard**] **Example:** RP/0/RSP0/CPU0:router(config-mstp-if)# **portfast** RP/0/RSP0/CPU0:router(config-mstp-if)# **portfast bpduguard**	Enables PortFast on the port, and optionally enables BPDU guard.
Step 21	**guard root** **Example:** RP/0/RSP0/CPU0:router(config-mstp-if)# **guard root**	Enables RootGuard on the port.

	Command or Action	Purpose
Step 22	**guard topology-change** **Example:** `RP/0/RSP0/CPU0:router(config-mstp-if)# guard topology-change`	Enables TopologyChangeGuard on the port. **Note** Repeat steps 14 to 22 for each interface.
Step 23	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-mstp-if)# end` or `RP/0/RSP0/CPU0:router(config-mstp-if)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Verifying MSTP

These show commands allow you to verify the operation of MSTP:

- **show spanning-tree mst** *mst-name*
- **show spanning-tree mst** *mst-name* **interface** *interface-name*
- **show spanning-tree mst** *mst-name* **errors**
- **show spanning-tree mst** *mst-name* **configuration**
- **show spanning-tree mst** *mst-name* **bpdu interface** *interface-name*
- **show spanning-tree mst** *mst-name* **topology-change flushes**

Configuring MSTAG or REPAG

This section describes the procedures for configuring MSTAG:

- Configuring an untagged subinterface
- Enabling MSTAG
- Configuring MSTAG parameters
- Configuring MSTAG Topology Change Propagation
- Verifying MSTAG

Note The procedures for configuring REPAG are identical.

This section does not describe how to configure data switching. Refer to the *Implementing Multipoint Layer 2 Services* module for more information.

Configuring an untagged subinterface

In order to enable MSTAG on a physical or Bundle Ethernet interface, an L2 subinterface must first be configured which matches untagged packets, using the **encapsulation untagged** command. Refer to The Cisco ASR 9000 Series Routers Carrier Ethernet Model module for more information about configuring L2 subinterfaces.

Enabling MSTAG

MSTAG is enabled on a physical or Bundle Ethernet interface by explicitly configuring it on the corresponding untagged subinterface. When MSTAG is configured on the untagged subinterface, it is automatically enabled on the physical or Bundle Ethernet interface and on all other subinterfaces on that physical or Bundle Ethernet subinterface.

Configuring MSTAG parameters

MSTAG parameters are configured separately on each interface, and MSTAG runs completely independently on each interface. There is no interaction between the MSTAG parameters on different interfaces (unless they are connected to the same access network).

These parameters are configurable for each interface:

- Region Name and Revision
- Bridge ID
- Port ID
- External port path cost
- Max Age
- Provide Bridge mode
- Hello Time

The following MSTAG parameters are configurable for each interface, for each spanning tree instance:

- VLAN IDs
- Root Bridge Priority and ID
- Bridge Priority
- Port Priority
- Internal Port Path Cost

To ensure consistent operation across the access network, these guidelines should be used when configuring:

- Both gateway devices should be configured with a Root Bridge Priority and ID (for each spanning tree instance) that is better (lower) than the Bridge Priority and Bridge ID of any device in the access network. It is recommended to set the Root Bridge Priority and ID to 0 on the gateway devices.

Note To avoid an STP dispute being detected by the access devices, the same root priority and ID should be configured on both gateway devices.

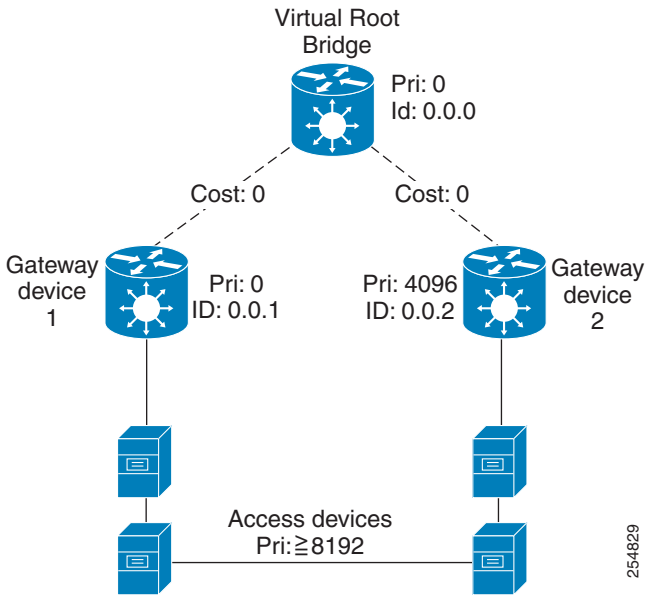
- Both gateway devices should be configured with a Port Path Cost of 0.
- For each spanning tree instance, one gateway device should be configured with the bridge priority and ID that is higher than the root bridge priority and ID, but lower than the bridge priority and ID of any other device in the network (including the other gateway device). It is recommended to set the bridge priority to 0.
- For each spanning tree instance, the second gateway device should be configured with a bridge priority and ID that is higher than the root bridge priority and ID and the first gateway device bridge priority and ID, but lower than the bridge priority and ID of any device in the access network. It is recommended to set the bridge priority to 4096 (this is the lowest allowable value greater than 0).
- All of the access devices should be configured with a higher bridge priority than the gateway devices. It is recommended to use values of 8192 or higher.
- For each spanning tree instance, the port path cost and other parameters may be configured on the access devices so as to ensure the desired port is put into the blocked state when all links are up.

Caution There are no checks on MSTAG configuration—misconfiguration may result in incorrect operation of the MSTP protocol in the access devices (for example, an STP dispute being detected).

The guidelines above are illustrated in Figure 34.

Note These guidelines do not apply to REPAG, as in that case the access devices ignore the information received from the gateway devices apart from when a topology change is signalled.

Figure 34 MSTAG Guidelines



Note The configuration steps listed in the following sections show all of the configurable parameters. However, in general, most of these can be retained with the default values.

SUMMARY STEPS

1. **configure**
2. **spanning-tree mstag** *protocol instance identifier*
3. **preempt delay for** *interval* {**seconds** | **minutes** | **hours**}
4. **interface {Bundle-Ether | GigabitEthernet | TenGigE | FastEthernet}** instance.subinterface
5. **name** *name*
6. **revision** *revision*-number
7. **max age** *seconds*
8. **provider-bridge**
9. **bridge-id** *id*
10. **port-id** *id*
11. **external-cost** *cost*
12. **hello-time** *seconds*
13. **instance** *id*
14. **vlan-id** *vlan-range* [,*vlan-range*][,*vlan-range*][,*vlan-range*]
15. **priority** *priority*
16. **port-priority** *priority*
17. **cost** *cost*
18. **root-bridge** *id*

19. **root-priority** *priority*
20. **end**
    or
    commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure` `Thu Jun  4 07:50:02.660 PST` `RP/0/RSP0/CPU0:router(config)#`	Enters global configuration mode.
Step 2	**spanning-tree mstag** *protocol instance identifier* **Example:** `RP/0/RSP0/CPU0:router(config)#` `spanning-tree mstag a` `RP/0/RSP0/CPU0:router(config-mstag)#`	Enters the MSTAG configuration submode.
Step 3	**preempt delay for** interval **{seconds | minutes | hours}** **Example:** `RP/0/RSP0/CPU0:router(config-mstag)#` `preempt delay for 10 seconds`	Specifies the delay period during which startup BPDUs should be sent, before preempting.
Step 4	**interface {Bundle-Ether | GigabitEthernet | TenGigE | FastEthernet}** instance.subinterface **Example:** `RP/0/RSP0/CPU0:router(config-mstag)#` `interface GigabitEthernet0/2/0/30.1` `RP/0/RSP0/CPU0:router(config-mstag-if)#`	Enters the MSTAG interface configuration submode, and enables MSTAG for the specified port.
Step 5	**name** *name* **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if)#` `name leo`	Sets the name of the MSTP region. The default value is the MAC address of the switch, formatted as a text string using the hexadecimal representation specified in IEEE Standard 802.
Step 6	**revision** *revision*-number **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if)#` `revision 1`	Sets the revision level of the MSTP region. Allowed values are from 0 through 65535.

	Command or Action	Purpose
Step 7	**max age** *seconds* **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if)# max age 20`	Sets the maximum age performance parameters for the bridge. Allowed values for the maximum age time for the bridge in seconds are from 6 through 40.
Step 8	**provider-bridge** **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if)# provider-bridge`	Places the current instance of the protocol in 802.1ad mode.
Step 9	**bridge-id** *id* **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if)# bridge-id 001c.0000.0011`	Sets the bridge ID for the current switch.
Step 10	**port-id** *id* **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if)# port-id 111`	Sets the port ID for the current switch.
Step 11	**external-cost** *cost* **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if)# external-cost 10000`	Sets the external path cost on the current port. Allowed values for port cost are from 1 through 200000000.
Step 12	**hello-time** *seconds* **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if)# hello-time 1`	Sets the port hello time in seconds. Allowed values are from 1 through 2.
Step 13	**instance** *id* **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if)# instance 1`	Enters the MSTI configuration submode. Allowed values for the MSTI ID are from 0 through 4094.
Step 14	**edge mode** **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if-inst)# edge mode`	Enables access gateway edge mode for this MSTI.
Step 15	**vlan-id** *vlan-range* [,*vlan-range*][,*vlan-range*][,*vlan-range*] **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if-inst)# vlan-id 2-1005`	Associates a set of VLAN IDs with the current MSTI. List of VLAN ranges in the form a-b, c, d, e-f, g, and so on.

	Command or Action	Purpose
Step 16	**priority** *priority* **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if-inst)# priority 4096`	Sets the bridge priority for the current MSTI. Allowed values are from 0 through 61440 in multiples of 4096.
Step 17	**port-priority** *priority* **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if-inst)# port-priority 160`	Sets the port priority performance parameter for the MSTI. Allowed values for port priority are from 0 through 240 in multiples of 16.
Step 18	**cost** *cost* **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if-inst)# cost 10000`	Sets the internal path cost for a given instance on the current port. Allowed values for port cost are from 1 through 200000000.
Step 19	**root-bridge** *id* **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if-inst)# root-id 001c.0000.0011`	Sets the root bridge ID for the BPDUs sent from the current port.
Step 20	**root-priority** *priority* **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if-inst)# root-priority 4096`	Sets the root bridge priority for the BPDUs sent from this port. **Note** Repeat steps 4 to 19 to configure each interface, and repeat steps 13 to 19 to configure each MSTI for each interface.
Step 21	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-mstag-if-inst)# end` or `RP/0/RSP0/CPU0:router(config-mstag-if-inst)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring MSTAG Topology Change Propagation

MSTAG Topology Change Propagation is configured simply by configuring connectivity between the MSTAG-enabled interfaces on the two gateway devices:

1. Configure MSTAG as described above. Take note of the untagged subinterface that is used.
2. Configure connectivity between the gateway devices. This may be via an MPLS Pseudowire, or may be a VLAN subinterface if there is a direct physical link.
3. Configure a point-to-point (P2P) cross-connect on each gateway device that contains the untagged subinterface and the link (PW or subinterface) to the other gateway device.

Once the untagged subinterface that is configured for MSTAG is added to the P2P cross-connect, MSTAG Topology Change Propagation is automatically enabled. MSTAG forwards BDPUs via the cross-connect to the other gateway device, so as to signal when a topology change has been detected.

For more information on configuring MPLS pseudowire or P2P cross-connects, refer to the Implementing Point to Point Layer 2 Services module.

Verifying MSTAG

These show commands allow you to verify the operation of MSTAG:

- **show spanning-tree mstag** *mst-name*
- **show spanning-tree mstag** *mst-name* **bpdu interface** *interface-name*
- **show spanning-tree mstag** *mst-name* **topology-change flushes**

Analogous commands are available for REPAG.

Configuring PVSTAG or PVRSTAG

This section describes the procedures for configuring PVSTAG:

- Enabling PVSTAG
- Configuring PVSTAG parameters
- Configuring Subinterfaces
- Verifying PVSTAG

The procedures for configuring PVRSTAG are identical.

Note This section does not describe how to configure data switching. Refer to the *Implementing Multipoint Layer 2 Services* module for more information.

Enabling PVSTAG

PVSTAG is enabled for a particular VLAN, on a physical interface, by explicit configuration of that physical interface and VLAN for PVSTAG.

Configuring PVSTAG parameters

The configurable PVSTAG parameters for each interface on each VLAN are:

- Root Priority and ID
- Root cost
- Bridge Priority and ID
- Port priority and ID
- Max Age
- Hello Time

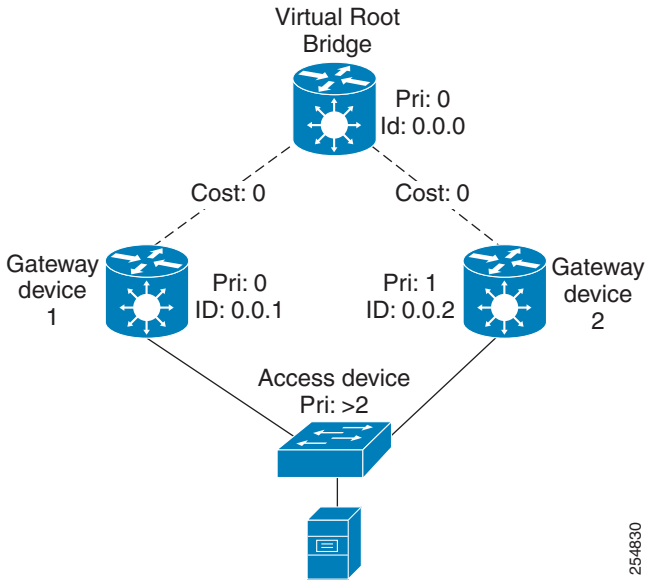
For correct operation, these guidelines must be followed when configuring PVSTAG.

- Both gateway devices should be configured with a root bridge priority and ID that is better (lower) than the bridge priority and Bridge ID of any device in the access network. It is recommended that you set the root bridge priority and ID to 0 on the gateway devices.
- Both gateway devices should be configured with a root cost of 0.
- One gateway device should be configured with the bridge priority and ID that is higher than the root bridge priority and ID, but lower than the bridge priority and ID of any other device in the network (including the other gateway device). It is recommended that you set the bridge priority to 0.
- The second gateway device should be configured with a bridge priority and ID that is higher than the root bridge priority and ID and the first gateway device bridge priority and ID, but lower than the bridge priority and ID of any device in the access network. It is recommended that you set the bridge priority to 1 for PVSTAG or 4096 for PVRSTAG. (For PVRSTAG, this is the lowest allowable value greater than 0.)
- All access devices must be configured with a higher bridge priority than the gateway devices. It is recommended that you use values of 2 or higher for PVSTAG, or 8192 or higher for PVRSTAG.
- For each spanning tree instance, the port path cost and other parameters may be configured on the access devices, so as to ensure the desired port is placed into the blocked state when all links are up.

Caution There are no checks on PVSTAG configuration—misconfiguration may result in incorrect operation of the PVST protocol in the access devices (for example, an STP *dispute* being detected).

These guidelines are illustrated in Figure 35.

Figure 35 PVSTAG Guidelines



Note The configuration steps listed in the following sections show all of the configurable parameters. However, in general, most of these can be retained with the default values.

PVSTAG Topology Restrictions

These restrictions are applicable to PVSTAG topology:

- Only a single access device can be attached to the gateway devices.
- Topology change notifications on a single VLAN affect all VLANs and bridge domains on that physical interface.

SUMMARY STEPS

1. **configure**
2. **spanning-tree pvstag** *protocol instance identifier*
3. **preempt delay for** *interval* {**seconds** | **minutes** | **hours**}
4. **interface** *interface-instance.subinterface*
5. **vlan** *vlan-id*
6. **root-priority** *priority*
7. **root-id** *id*
8. **root-cost** *cost*
9. **priority** *priority*
10. **bridge-id** *id*
11. **port-priority** *priority*
12. **port-id** *id*

13. **hello-time** *seconds*
14. **max age** *seconds*
15. **end**
    or
    commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure` `Thu Jun  4 07:50:02.660 PST` `RP/0/RSP0/CPU0:router(config)#`	Enters global configuration mode.
Step 2	**spanning-tree pvstag** *protocol instance identifier* **Example:** `RP/0/RSP0/CPU0:router(config)#` `spanning-tree pvstag a` `RP/0/RSP0/CPU0:router(config-pvstag)#`	Enters the PVSTAG configuration submode.
Step 3	**preempt delay for** interval **{seconds | minutes | hours}** **Example:** `RP/0/RSP0/CPU0:router(config-pvstag)#` `preempt delay for 10 seconds`	Specifies the delay period during which startup BPDUs should be sent, before preempting.
Step 4	**interface** *interface*-instance.subinterface **Example:** `RP/0/RSP0/CPU0:router(config-pvstag)#` `interface GigabitEthernet0/2/0/30.1` `RP/0/RSP0/CPU0:router(config-pvstag-if)#`	Enters the PVSTAG interface configuration submode, and enables PVSTAG for the specified port.
Step 5	**vlan** *vlan-id* **Example:** `RP/0/RSP0/CPU0:router(config-pvstag-if)#` `vlan 200`	Enables and configures a VLAN on this interface.
Step 6	**root-priority** *priority* **Example:** `RP/0/RSP0/CPU0:router(config-pvstag-if-vlan)# root-priority 4096`	Sets the root bridge priority for the BPDUs sent from this port.
Step 7	**root-id** *id* **Example:** `RP/0/RSP0/CPU0:router(config-pvstag-if-vlan)# root-id 0000.0000.0000`	Sets the identifier of the root bridge for BPDUs sent from a port.
Step 8	**root-cost** *cost* **Example:** `RP/0/RSP0/CPU0:router(config-pvstag-if-vlan)# root-cost 10000`	Set the root path cost to sent in BPDUs from this interface.

	Command or Action	Purpose
Step 9	**priority** *priority* **Example:** `RP/0/RSP0/CPU0:router(config-pvstag-if-vlan)# priority 4096`	Sets the bridge priority for the current MSTI. For PVSTAG, allowed values are from are 0 through 65535; for PVRSTAG, the allowed values are from 0 through 61440 in multiples of 4096.
Step 10	**bridge-id** *id* **Example:** `RP/0/RSP0/CPU0:router(config-pvstag-if-vlan)# bridge-id 001c.0000.0011`	Sets the bridge ID for the current switch.
Step 11	**port-priority** *priority* **Example:** `RP/0/RSP0/CPU0:router(config-pvstag-if-vlan)# port-priority 160`	Sets the port priority performance parameter for the MSTI. For PVSTAG, allowed values for port priority are from 0 through 255; for PVRSTAG, the allowed values are from 0 through 240 in multiples of 16.
Step 12	**port-id** *id* **Example:** `RP/0/RSP0/CPU0:router(config-pvstag-if-vlan)# port-id 111`	Sets the port ID for the current switch.
Step 13	**hello-time** *seconds* **Example:** `RP/0/RSP0/CPU0:router(config-pvstag-if-vlan)# hello-time 1`	Sets the port hello time in seconds. Allowed values are from 1 through 2.

	Command or Action	Purpose
Step 14	**max age** *seconds* **Example:** `RP/0/RSP0/CPU0:router(config-pvstag-if-vlan)# max age 20`	Sets the maximum age performance parameters for the bridge. Allowed values for the maximum age time for the bridge in seconds are from 6 through 40. **Note** Repeat steps 4 to 14 to configure each interface; repeat steps 5 to 14 to configure each VLAN on each interface.
Step 15	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-pvstag-if-vlan)# end` or `RP/0/RSP0/CPU0:router(config-pvstag-if-vlan)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Subinterfaces

For each VLAN that is enabled for PVSTAG on an interface, a corresponding subinterface that matches traffic for that VLAN must be configured. This is used both for data switching and for PVST BPDUs. Follow these guidelines when configuring subinterfaces:

- VLAN 1 is treated as the native VLAN in PVST. Therefore, for VLAN 1, a subinterface that matches untagged packets (**encapsulation untagged**) must be configured. It may also be necessary to configure a subinterface that matches packets tagged explicitly with VLAN 1 (**encapsulation dot1q 1**).
- Only dot1q packets are allowed in PVST; Q-in-Q and dot1ad packets are not supported by the protocol, and therefore subinterfaces configured with these encapsulation will not work correctly with PVSTAG.
- Subinterfaces that match a range of VLANs are supported by PVSTAG; it is not necessary to configure a separate subinterface for each VLAN, unless it is desirable for provisioning the data switching.
- PVSTAG does not support:
  - Physical interfaces configured in L2 mode
  - Subinterface configured with a default encapsulation (**encapsulation default**)
  - Subinterfaces configured to match any VLAN (**encapsulation dot1q any**)

For more information about configuring L2 subinterfaces, refer to the Implementing Point to Point Layer 2 Services module.

Verifying PVSTAG

These **show** commands allow you to verify the operation of PVSTAG or PVRSTAG:

- **show spanning-tree pvstag** *mst-name*
- **show spanning-tree pvstag** *mst-name*

In particular, these commands display the subinterface that is being used for each VLAN.

Configuring MVRP-lite

This section describes the procedure for configuring MVRP-lite:

- Enabling MVRP-lite
- Configuring MVRP-lite parameters
- Verifying MVRP-lite

Enabling MVRP-lite

When MVRP-lite is configured, it is automatically enabled on all interfaces where MSTP is enabled. MSTP must be configured before MVRP can be enabled. For more information on configuring MSTP, see Configuring MSTP, page 342.

Configuring MVRP-lite parameters

The configurable MVRP-lite parameters are:

- Periodic Transmission
- Join Time
- Leave Time
- Leave-all Time

Summary Steps

1. **configure**
2. **spanning-tree mst** *protocol instance name*
3. **mvrp static**
4. **periodic transmit** [**interval** *seconds*]
5. **join-time** *milliseconds*
6. **leave-time** *seconds*
7. **leaveall-time** *seconds*
8. **end**
   or
   commit

Detailed Steps

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure` `Thu Jun  4 07:50:02.660 PST` `RP/0/RSP0/CPU0:router(config)#`	Enters global configuration mode.
Step 2	**spanning-tree mst** *protocol instance identifier* **Example:** `RP/0/RSP0/CPU0:router(config)#` `spanning-tree mst a` `RP/0/RSP0/CPU0:router(config-mstp)#`	Enters the MSTP configuration submode.
Step 3	**mvrp static** **Example:** `RP/0/RSP0/CPU0:router(config-mstp)# mvrp static`	Configures MVRP to run over this MSTP protocol instance.
Step 4	**periodic transmit** [**interval** *seconds*] **Example:** `RP/0/RSP0/CPU0:router(config-mvrp)#` `periodic transmit`	Sends periodic Multiple VLAN Registration Protocol Data Unit (MVRPDU) on all active ports.
Step 5	**join-time** *milliseconds* **Example:** `RP/0/RSP0/CPU0:router(config-mvrp)#` `hello-time 1`	Sets the join time for all active ports.
Step 6	**leave-time** *seconds* **Example:** `RP/0/RSP0/CPU0:router(config-mvrp)#` `leave-time 20`	Sets the leave time for all active ports.

	Command or Action	Purpose
Step 7	**leaveall-time** *seconds* **Example:** `RP/0/RSP0/CPU0:router(config-mvrp)#` **`leaveall-time 20`**	Sets the leave all time for all active ports.
Step 8	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-mvrp)# end` or `RP/0/RSP0/CPU0:router(config-mvrp)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Verifying MVRP-lite

These show commands allow you to verify the operation of MVRP-lite:

- **show ethernet mvrp mad**
- **show ethernet mvrp status**
- **show ethernet mvrp statistics**

Configuration Examples for Implementing MSTP

This section provides configuration examples for the following:

- Configuring MSTP: Examples
- Configuring MSTAG: Examples
- Configuring PVSTAG: Examples
- Configuring MVRP-Lite: Examples

Configuring MSTP: Examples

This example shows MSTP configuration for a single spanning-tree instance with MSTP enabled on a single interface:

```
config
spanning-tree mst example
    name m1
    revision 10
    forward-delay 20
    maximum hops 40
    maximum age 40
    transmit hold-count 8
    provider-bridge
    bringup delay for 60 seconds
    flush containment disable
    instance 101
        vlans-id 101-110
        priority 8192
    !
    interface GigabitEthernet0/0/0/0
        hello-time 1
        external-cost 10000
        link-type point-to-point
        portfast
        guard root
        guard topology-change
        instance 101 cost 10000
        instance 101 port-priority 160
    !
!
```

This example shows the output from the **show spanning-tree mst** command, which produces an overview of the spanning tree protocol state:

```
# show spanning-tree mst example
Role:  ROOT=Root, DSGN=Designated, ALT=Alternate, BKP=Backup, MSTR=Master
State: FWD=Forwarding, LRN=Learning, BLK=Blocked, DLY=Bringup Delayed

Operating in dot1q mode


MSTI 0 (CIST):

  VLANS Mapped: 1-9,11-4094

  CIST Root  Priority    4096
             Address     6262.6262.6262
             This bridge is the CIST root
```

```
             Ext Cost    0

  Root ID    Priority    4096
             Address     6262.6262.6262
             This bridge is the root
             Int Cost    0
             Max Age 20 sec, Forward Delay 15 sec


  Bridge ID  Priority    4096 (priority 4096 sys-id-ext 0)
             Address     6262.6262.6262
             Max Age 20 sec, Forward Delay 15 sec
             Max Hops 20, Transmit Hold count  6
Interface    Port ID           Role State Designated           Port ID
             Pri.Nbr Cost                 Bridge ID            Pri.Nbr
------------ ------- --------- ---- ----- -------------------- -------
Gi0/0/0/0    128.1   20000     DSGN FWD   4096  6262.6262.6262 128.1
Gi0/0/0/1    128.2   20000     DSGN FWD   4096  6262.6262.6262 128.2
Gi0/0/0/2    128.3   20000     DSGN FWD   4096  6262.6262.6262 128.3
Gi0/0/0/3    128.4   20000     ---- BLK   ----- -------------- -------


MSTI 1:

  VLANS Mapped: 10

  Root ID    Priority    4096
             Address     6161.6161.6161
             Int Cost    20000
             Max Age 20 sec, Forward Delay 15 sec


  Bridge ID  Priority    32768 (priority 32768 sys-id-ext 0)
             Address     6262.6262.6262
             Max Age 20 sec, Forward Delay 15 sec
             Max Hops 20, Transmit Hold count  6


Interface    Port ID           Role State Designated           Port ID
             Pri.Nbr Cost                 Bridge ID            Pri.Nbr
------------ ------- --------- ---- ----- -------------------- -------
Gi0/0/0/0    128.1   20000     ROOT FWD   4096  6161.6161.6161 128.1
Gi0/0/0/1    128.2   20000     ALT  BLK   4096  6161.6161.6161 128.2
Gi0/0/0/2    128.3   20000     DSGN FWD   32768 6262.6262.6262 128.3
Gi0/0/0/3    128.4   20000     ---- BLK   ----- -------------- -------

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

In the **show spanning-tree mst** *example* output, the first line indicates whether MSTP is operating in dot1q or the Provider Bridge mode, and this information is followed by details for each MSTI.

For each MSTI, the following information is displayed:

- The list of VLANs for the MSTI.
- For the CIST, the priority and bridge ID of the CIST root, and the external path cost to reach the CIST root. The output also indicates if this bridge is the CIST root.
- The priority and bridge ID of the root bridge for this MSTI, and the internal path cost to reach the root. The output also indicates if this bridge is the root for the MSTI.
- The max age and forward delay times received from the root bridge for the MSTI.
- The priority and bridge ID of this bridge, for this MSTI.

- The maximum age, forward delay, max hops and transmit hold-count for this bridge (which is the same for every MSTI).
- A list of MSTP-enabled interfaces. For each interface, the following information is displayed:
  - The interface name
  - The port priority and port ID for this interface for this MSTI.
  - The port cost for this interface for this MSTI.
  - The current port role:

    DSGN—Designated: This is the designated port on this LAN, for this MSTI

    ROOT—Root: This is the root port for the bridge for this MSTI.

    ALT—Alternate: This is an alternate port for this MSTI.

    BKP—Backup: This is a backup port for this MSTI

    MSTR—Master: This is a boundary port that is a root or alternate port for the CIST.

    The interface is down, or the bringup delay timer is running and no role has been assigned yet.
  - The current port state:

    BLK—The port is blocked.

    LRN—The port is learning.

    FWD—The port is forwarding.

    DLY—The bringup-delay timer is running.
  - If the port is a boundary port, and not CIST and the port is not designated, then only the BOUNDARY PORT is displayed and the remaining information is not displayed.
  - If the port is not up, or the bringup delay timer is running, no information is displayed for the remaining fields. Otherwise, the bridge priority and bridge ID of the designated bridge on the LAN that the interface connects to is displayed, followed by the port priority and port ID of the designated port on the LAN. If the port role is Designated, then the information for this bridge or port is displayed.

The following example shows the output from the **show spanning-tree mst** command, which produces more detailed information regarding interface state than the standard command as described above:

```
# show spanning-tree mst a interface GigabitEthernet0/1/2/1
GigabitEthernet0/1/2/1
Cost: 20000
link-type: point-to-point
hello-time 1
Portfast: no
BPDU Guard: no
Guard root: no
Guard topology change: no
BPDUs sent 492, received 3
```

```
MST 3:
    Edge port:
    Boundary : internal
    Designated forwarding
    Vlans mapped to MST 3: 1-2,4-2999,4000-4094
    Port info port id 128.193 cost 200000
    Designated root address 0050.3e66.d000 priority 8193 cost 20004
    Designated bridge address 0002.172c.f400 priority 49152 port id 128.193
    Timers: message expires in 0 sec, forward delay 0, forward transitions 1
    Transitions to reach this state: 12
```

The output includes interface information about the interface which applies to all MSTIs:

- Cost
- link-type
- hello-time
- portfast (including whether BPDU guard is enabled)
- guard root
- guard topology change
- BPDUs sent, received.

It also includes information specific to each MSTI:

- Port ID, priority, cost
- BPDU information from root (bridge ID, cost, and priority)
- BPDU information being sent on this port (Bridge ID, cost, priority)
- State transitions to reach this state.
- Topology changes to reach this state.
- Flush containment status for this MSTI.

This example shows the output of **show spanning-tree mst errors**, which produces information about interfaces that are configured for MSTP but where MSTP is not operational. Primarily this shows information about interfaces which do not exist:

```
# show spanning-tree mst a errors
Interface                Error
------------------------------
GigabitEthernet1/2/3/4   Interface does not exist.
```

This example shows the output of **show spanning-tree mst configuration**, which displays the VLAN ID to MSTI mapping table. It also displays the configuration digest which is included in the transmitted BPDUs—this must match the digest received from other bridges in the same MSTP region:

```
# show spanning-tree mst a configuration
Name          leo
Revision      2702
Config Digest 9D-14-5C-26-7D-BE-9F-B5-D8-93-44-1B-E3-BA-08-CE
Instance  Vlans mapped
--------  --------------------------------
0         1-9,11-19,21-29,31-39,41-4094
1         10,20,30,40
----------------------------------------
```

This example shows the output of **show spanning-tree mst bpdu interface**, which produces details on the BPDUs being output and received on a given local interface:

Note Several received packets can be stored in case of MSTP operating on a shared LAN.

```
# show spanning-tree mst a bpdu interface GigabitEthernet0/1/2/2 direction transmit
MSTI 0 (CIST):
    Root ID : 0004.9b78.0800
    Path Cost : 83
    Bridge ID : 0004.9b78.0800
    Port ID : 12
    Hello Time : 2
    ...
```

This example shows the output of **show spanning-tree mst topology-change flushes**, which displays details about the topology changes that have occurred for each MSTI on each interface:

```
# show spanning-tree mst M topology-change flushes instance$
MSTI 1:

Interface     Last TC               Reason                           Count
------------  --------------------  -------------------------------- -----
Te0/0/0/1     04:16:05 Mar 16 2010  Role change: DSGN to ----           10
#
#
# show spanning-tree mst M topology-change flushes instance$
MSTI 0 (CIST):

Interface     Last TC               Reason                           Count
------------  --------------------  -------------------------------- -----
Te0/0/0/1     04:16:05 Mar 16 2010  Role change: DSGN to ----           10
#
```

Configuring MSTAG: Examples

This example shows MSTAG configuration for a single spanning-tree instance on a single interface:

```
config
interface GigabitEthernet0/0/0/0.1 l2transport
    encapsulation untagged
!
spanning-tree mstag example
    preempt delay for 60 seconds
    interface GigabitEthernet0/0/0/0.1
        name m1
        revision 10
        external-cost 0
        bridge-id 0.0.1
        port-id 1
        maximum age 40
        provider-bridge
        hello-time 1
        instance 101
            edge-mode
            vlans-id 101-110
            root-priority 0
            root-id 0.0.0
```

```
            cost 0
            priority 0
            port-priority 0
        !
    !
!
```

This example shows additional configuration for MSTAG Topology Change Propagation:

```
l2vpn
    xconnect group example
        p2p mstag-example
            interface GigabitEthernet0/0/0/0.1
            neighbor 123.123.123.1 pw-id 100
        !
    !
!
```

This example shows the output of **show spanning-tree mstag**:

```
# show spanning-tree mstag A
GigabitEthernet0/0/0/1
  Preempt delay is disabled.
  Name:            6161:6161:6161
  Revision:        0
  Max Age:         20
  Provider Bridge: no
  Bridge ID:       6161.6161.6161
  Port ID:         1
  External Cost:   0
  Hello Time:      2
  Active:          no
  BPDUs sent:      0
    MSTI 0 (CIST):
    VLAN IDs:         1-9,32-39,41-4094
    Role:             Designated
    Bridge Priority:  32768
    Port Priority:    128
    Cost:             0
    Root Bridge:      6161.6161.6161
    Root Priority:    32768
    Topology Changes: 123
  MSTI 2
    VLAN IDs:         10-31
    Role:             Designated
    Bridge Priority:  32768
    Port Priority:    128
    Cost:             0
    Root Bridge:      6161.6161.6161
    Root Priority:    32768
    Topology Changes: 123
  MSTI 10
    VLAN IDs:         40
    Role:             Root (Edge mode)
    Bridge Priority:  32768
    Port Priority:    128
    Cost:             200000000
    Root Bridge:      6161.6161.6161
    Root Priority:    61440
    Topology Changes: 0
```

This example shows the output of **show spanning-tree mstag bpdu interface**, which produces details on the BPDUs being output and received on a given local interface:

```
RP/0/RSP0/CPU0:router#show spanning-tree mstag foo bpdu interface GigabitEthernet 0/0/0/0
Transmitted:
  MSTI 0 (CIST):
ProtocolIdentifier: 0
ProtocolVersionIdentifier: 3
BPDUType: 2
CISTFlags: Top Change Ack  0
           Agreement       1
           Forwarding      1
           Learning        1
           Role            3
           Proposal        0
           Topology Change 0
CISTRootIdentifier: priority 8, MSTI 0, address 6969.6969.6969
CISTExternalPathCost: 0
CISTRegionalRootIdentifier: priority 8, MSTI 0, address 6969.6969.6969
CISTPortIdentifierPriority: 8
CISTPortIdentifierId: 1
MessageAge: 0
MaxAge: 20
HelloTime: 2
ForwardDelay: 15
Version1Length: 0
Version3Length: 80
FormatSelector: 0
Name: 6969:6969:6969
Revision: 0
MD5Digest: ac36177f 50283cd4 b83821d8 ab26de62
CISTInternalRootPathCost: 0
CISTBridgeIdentifier: priority 8, MSTI 0, address 6969.6969.6969
CISTRemainingHops: 20
  MSTI 1:
MSTIFlags: Master          0
           Agreement       1
           Forwarding      1
           Learning        1
           Role            3
           Proposal        0
           Topology Change 0
MSTIRegionalRootIdentifier: priority 8, MSTI 1, address 6969.6969.6969
MSTIInternalRootPathCost: 0
MSTIBridgePriority: 1
MSTIPortPriority: 8
MSTIRemainingHops: 20
```

This example shows the output of **show spanning-tree mstag topology-change flushes**, which displays details about the topology changes that have occurred for each interface:

```
#show spanning-tree mstag b topology-change flushes

MSTAG Protocol Instance b

Interface     Last TC              Reason                            Count
------------  -------------------  --------------------------------- -----
Gi0/0/0/1     18:03:24 2009-07-14  Gi0/0/0/1.10 egress TCN           65535
Gi0/0/0/2     21:05:04 2009-07-15  Gi0/0/0/2.1234567890 ingress TCN      2
```

Configuring PVSTAG: Examples

This example shows PVSTAG configuration for a single VLAN on a single interface:

```
config
spanning-tree pvstag example
    preempt delay for 60 seconds
    interface GigabitEthernet0/0/0/0
        vlan 10
            root-priority 0
            root-id 0.0.0
            root-cost 0
            priority 0
            bridge-id 0.0.1
            port-priority 0
            port-id 1
            max age 40
            hello-time 1
        !
    !
!
```

This example shows the output of **show spanning-tree pvstag**:

```
# show spanning-tree pvstag interface GigabitEthernet0/0/0/1
GigabitEthernet0/0/0/1
  VLAN 10
    Preempt delay is disabled.
    Sub-interface:    GigabitEthernet0/0/0/1.20 (Up)
    Max Age:          20
    Root Priority:    0
    Root Bridge:      0000.0000.0000
    Cost:             0
    Bridge Priority:  32768
    Bridge ID:        6161.6161.6161
    Port Priority:    128
    Port ID:          1
    Hello Time:       2
    Active:           no
    BPDUs sent:       0
    Topology Changes: 123
   VLAN 20
```

Configuring MVRP-Lite: Examples

This example shows MVRP-lite configuration:

```
config
spanning-tree mst example
    mvrp static
        periodic transmit
        join-time 200
        leave-time 30
        leaveall-time 10
    !
!
```

This example shows the output of **show ethernet mvrp mad**:

```
RP/0/RSP0/CPU0:router# show ethernet mvrp mad interface GigabitEthernet 0/1/0/1
GigabitEthernet0/1/0/1
  Participant Type: Full; Point-to-Point: Yes
  Admin Control: Applicant Normal; Registrar Normal

  LeaveAll Passive (next in 5.92s); periodic disabled
  Leave in 25.70s; Join not running
  Last peer 0293.6926.9585; failed registrations: 0

VID   Applicant              Registrar
----  ---------------------  ---------
   1  Very Anxious Observer  Leaving
 283  Quiet Passive          Empty
```

This example shows the output of **show ethernet mvrp status**:

```
RP/0/RSP0/CPU0:router# show ethernet mvrp status interface GigabitEthernet 0/1/0/1
GigabitEthernet0/1/0/1
  Statically declared:  1-512,768,980-1034
  Dynamically declared: 2048-3084
  Registered:           1-512
```

This example shows the output of **show ethernet mvrp statistics**:

```
RP/0/RSP0/CPU0:router# show ethernet mvrp statistics interface GigabitEthernet 0/1/0/1
GigabitEthernet0/1/0/1
  MVRPDUs TX:    1245
  MVRPDUs RX:       7
  Dropped TX:       0
  Dropped RX:      42
  Invalid RX:      12
```

Additional References

These sections provide references related to implementing Multiple Spanning Tree Protocol (MSTP) on Cisco ASR 9000 Series Routers.

Related Documents

Related Topic	Document Title
Multiple Spanning Tree Protocol Commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples	*Multiple Spanning Tree Protocol Commands* module in *Cisco ASR 9000 Series Aggregation Services Router L2VPN and Ethernet Services Command Reference*

Standards

Standards	Title
IEEE 802.1Q-2005	IEEE Standard for Local and Metropolitan Area Networks - Virtual Bridged Local Area Networks

MIBs

MIBs	MIBs Link
—	To locate and download MIBs using Cisco IOS XR software, use the Cisco MIB Locator found at this URL and choose a platform under the Cisco Access Products menu: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport

Implementing Layer 2 Access Lists

An Ethernet services access control list (ACL) consists of one or more access control entries (ACE) that collectively define the Layer 2 network traffic profile. This profile can then be referenced by Cisco IOS XR software features. Each Ethernet services ACL includes an action element (permit or deny) based on criteria such as source and destination address, Class of Service (CoS), or VLAN ID.

This module describes tasks required to implement Ethernet services access lists on your Cisco ASR 9000 Series Aggregation Services Router.

Note For a complete description of the Ethernet services access list commands listed in this module, refer to the *Ethernet Services (Layer 2) Access List Commands on Cisco ASR 9000 Series Routers* module in the *Cisco ASR 9000 Series Aggregation Services Router IP Addresses and Services Command Reference* publication. To locate documentation of other commands that appear in this chapter, use the command reference master index, or search online.

Feature History for Implementing Ethernet Services Access Lists on Cisco ASR 9000 Series Routers

Release	Modification
Release 3.7.2	This feature was introduced on Cisco ASR 9000 Series Routers.

Contents

Prerequisites for Implementing Layer 2 Access Lists

This prerequisite applies to implementing access lists and prefix lists:

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.

Information About Implementing Layer 2 Access Lists

To implement Ethernet services access lists, you must understand these concepts:

Ethernet Services Access Lists Feature Highlights

Ethernet services access lists have these feature highlights:

- The ability to clear counters for an access list using a specific sequence number.
- The ability to copy the contents of an existing access list to another access list.
- Allows users to apply sequence numbers to permit or deny statements and to resequence, add, or remove such statements from a named access list.
- Provides packet filtering on interfaces to forward packets.
- Ethernet services ACLs can be applied on interfaces, VLAN subinterfaces, bundle-Ethernet interfaces, EFPs, and EFPs over bundle-Ethernet interfaces. Atomic replacement of Ethernet services ACLs is supported on these physical interfaces.

Purpose of Ethernet Services Access Lists

Using ACL-based forwarding (ABF), Ethernet services access lists perform packet filtering to control which packets move through the network and where. Such controls help to limit incoming and outgoing network traffic and restrict the access of users and devices to the network at the port level.

How an Ethernet Services Access List Works

An Ethernet services access list is a sequential list consisting of permit and deny statements that apply to Layer 2 configurations. The access list has a name by which it is referenced.

An access list can be configured and named, but it is not in effect until the access list is referenced by a command that accepts an access list. Multiple commands can reference the same access list. An access list can control Layer 2 traffic arriving at the router or leaving the router, but not traffic originating at the router.

Ethernet Services Access List Process and Rules

Use this process and rules when configuring an Ethernet services access list:

- The software tests the source or destination address of each packet being filtered against the conditions in the access list, one condition (permit or deny statement) at a time.
- If a packet does not match an access list statement, the packet is then tested against the next statement in the list.
- If a packet and an access list statement match, the remaining statements in the list are skipped and the packet is permitted or denied as specified in the matched statement. The first entry that the packet matches determines whether the software permits or denies the packet. That is, after the first match, no subsequent entries are considered.
- If the access list denies the address or protocol, the software discards the packet.
- If no conditions match, the software drops the packet because each access list ends with an unwritten or implicit deny statement. That is, if the packet has not been permitted or denied by the time it was tested against each statement, it is denied.
- The access list should contain at least one permit statement or else all packets are denied.
- Because the software stops testing conditions after the first match, the order of the conditions is critical. The same permit or deny statements specified in a different order could result in a packet being passed under one circumstance and denied in another circumstance.
- Inbound access lists process packets arriving at the router. Incoming packets are processed before being routed to an outbound interface. An inbound access list is efficient because it saves the overhead of routing lookups if the packet is to be discarded because it is denied by the filtering tests. If the packet is permitted by the tests, it is then processed for routing. For inbound lists, permit means continue to process the packet after receiving it on an inbound interface; deny means discard the packet.
- Outbound access lists process packets before they leave the router. Incoming packets are routed to the outbound interface and then processed through the outbound access list. For outbound lists, permit means send it to the output buffer; deny means discard the packet.
- An access list can not be removed if that access list is being applied by an access group in use. To remove an access list, remove the access group that is referencing the access list and then remove the access list.
- An access list must exist before you can use the **ethernet-services access-group** command.

Helpful Hints for Creating Ethernet Services Access Lists

Consider these when creating an Ethernet services access list:

- Create the access list before applying it to an interface.
- Organize your access list so that more specific references appear before more general ones.

Source and Destination Addresses

Source MAC address and destination MAC address are two of the most typical fields on which to base an access list. Specify source MAC addresses to control packets from certain networking devices or hosts. Specify destination MAC addresses to control packets being sent to certain networking devices or hosts.

Ethernet Services Access List Entry Sequence Numbering

The ability to apply sequence numbers to Ethernet services access-list entries simplifies access list changes. The access list entry sequence numbering feature allows you to add sequence numbers to access-list entries and resequence them. When you add a new entry, you choose the sequence number so that it is in a desired position in the access list. If necessary, entries currently in the access list can be resequenced to create room to insert the new entry.

Sequence Numbering Behavior

These details the sequence numbering behavior:

- If entries with no sequence numbers are applied, the first entry is assigned a sequence number of 10, and successive entries are incremented by 10. The maximum sequence number is 2147483646. If the generated sequence number exceeds this maximum number, this message is displayed:

  ```
  Exceeded maximum sequence number.
  ```

- If you provide an entry without a sequence number, it is assigned a sequence number that is 10 greater than the last sequence number in that access list and is placed at the end of the list.
- ACL entries can be added without affecting traffic flow and hardware performance.
- Distributed support is provided so that the sequence numbers of entries in the route-switch processor (RSP) and interface card are synchronized at all times.

How to Implement Layer 2 Access Lists

This section contains these procedures:

- Restrictions for Implementing Layer 2 Access Lists, page 380
- Configuring Ethernet Services Access Lists, page 381 (optional)
- Applying Ethernet Services Access Lists, page 382 (optional)
- Resequencing Access-List Entries, page 385 (optional)

Restrictions for Implementing Layer 2 Access Lists

These restrictions apply to implementing Ethernet services access lists:

- Ethernet services access lists are not supported over management interfaces.
- NetIO (software slow path) is not supported for Ethernet services access lists.

Configuring Ethernet Services Access Lists

This task configures an Ethernet services access list.

SUMMARY STEPS

1. **configure**
2. **ethernet-service access-list** *name*
3. [*sequence-number*] **{permit | deny}** {*src-mac-address src-mac-mask* **| any | host**} [{*ethertype-number*} | **vlan** *min-vlan-ID* [*max-vlan-ID*]] [**cos** *cos-value*] [**dei**] [**inner-vlan** *min-vlan-ID* [*max-vlan-ID*]] [**inner-cos** *cos-value*] [**inner-dei**]
4. Repeat Step 3 as necessary, adding statements by sequence number where you planned. Use the **no** *sequence-number* command to delete an entry.
5. **end**
   or
   commit
6. **show access-lists ethernet-services** [*access-list-name* | **maximum** | **standby** | **summary**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet-service access-list** *name* **Example:** `RP/0/RSP0/CPU0:router(config)# ethernet-service access-list L2ACL2`	Enters Ethernet services access list configuration mode and configures access list L2ACL2.
Step 3	[*sequence-number*] **{permit | deny}** {*src-mac-address src-mac-mask* **| any | host**} [{*ethertype-number*} | **vlan** *min-vlan-ID* [*max-vlan-ID*]] [**cos** *cos-value*] [**dei**] [**inner-vlan** *min-vlan-ID* [*max-vlan-ID*]] [**inner-cos** *cos-value*] [**inner-dei**] **Example:** `RP/0/RSP0/CPU0:router(config-es-al)# 20 permit 1.2.3 3.2.1` or `RP/0/RSP0/CPU0:router(config-es-al)# 30 deny any dei`	Specifies one or more conditions allowed or denied, which determines whether the packet is passed or dropped.
Step 4	Repeat Step 3 as necessary, adding statements by sequence number where you planned. Use the **no** *sequence-number* command to delete an entry.	Allows you to revise an access list.

	Command or Action	Purpose
Step 5	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-es-acl)# end` or `RP/0/RSP0/CPU0:router(config-es-acl)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 6	**show access-lists ethernet-services** [*access-list-name* | **maximum** | **standby** | **summary**] **Example:** `RP/0/RSP0/CPU0:router# show access-lists ethernet-services L2ACL1`	(Optional) Displays the contents of the named Ethernet services access list. • As a default, contents of all Ethernet access lists are displayed.

What to Do Next

After creating an Ethernet services access list, you must apply it to an interface. See the Applying Ethernet Services Access Lists section for information about how to apply an access list.

Applying Ethernet Services Access Lists

After you create an access list, you must reference the access list to make it work. Access lists can be applied on either outbound or inbound interfaces. This section describes guidelines on how to accomplish this task for both terminal lines and network interfaces.

For inbound access lists, after receiving a packet, Cisco IOS XR software checks the source MAC address of the packet against the access list. If the access list permits the address, the software continues to process the packet. If the access list rejects the address, the software discards the packet.

For outbound access lists, after receiving and routing a packet to a controlled interface, the software checks the source MAC address of the packet against the access list. If the access list permits the address, the software sends the packet. If the access list rejects the address, the software discards the packet.

Note An empty access-list (containing no access control elements) cannot be applied on an interface.

Controlling Access to an Interface

This task applies an access list to an interface to restrict access to that interface. Access lists can be applied on either outbound or inbound interfaces.

SUMMARY STEPS

1. **configure**
2. **interface** *type instance*
3. **ethernet-service access-group** *access-list-name* {**ingress** | **egress**}
4. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RSP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface** *type instance* **Example:** `RP/0/RSP0/CPU0:router(config)# interface gigabitethernet 0/2/0/2`	Configures an interface and enters interface configuration mode. • The *type* argument specifies an interface type. For more information on interface types, use the question mark (**?**) online help function. • The *instance* argument specifies either a physical interface instance or a virtual instance. – The naming notation for a physical interface instance is *rack/slot/module/port*. The slash (/) between values is required as part of the notation. – The number range for a virtual interface instance varies depending on the interface type.
Step 3	**ethernet-services access-group** *access-list-name* {**ingress** | **egress**} **Example:** `RP/0/RSP0/CPU0:router(config-if)# ethernet-services access-group p-in-filter ingress` `RP/0/RSP0/CPU0:router(config-if)# ethernet-services access-group p-out-filter egress`	Controls access to an interface. • Use the *access-list-name* argument to specify a particular Ethernet services access list. • Use the **ingress** keyword to filter on inbound packets or the **egress** keyword to filter on outbound packets. This example applies filters on packets inbound and outbound from GigabitEthernet interface 0/2/0/2.

	Command or Action	Purpose
Step 4	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router(config-if)# end` or `RP/0/RSP0/CPU0:router(config-if)# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Copying Ethernet Services Access Lists

This task copies an Ethernet services access list.

SUMMARY STEPS

1. **copy access-list ethernet-service** *source-acl destination-acl*
2. **show access-lists ethernet-services** [*access-list-name* | **maximum** | **standby** | **summary**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**copy access-list ethernet-service** *source-acl destination-acl* **Example:** `RP/0/RSP0/CPU0:router# copy access-list ethernet-service list-1 list-2`	Creates a copy of an existing Ethernet services access list. • Use the *source-acl* argument to specify the name of the access list to be copied. • Use the *destination-acl* argument to specify where to copy the contents of the source access list. – The *destination-acl* argument must be a unique name; if the *destination-acl* argument name exists for an access list, the access list is not copied.
Step 2	**show access-lists ethernet-services** [*access-list-name*	**maximum**	**standby**	**summary**] **Example:** `RP/0/RSP0/CPU0:router# show access-lists ethernet-services list-2`	(Optional) Displays the contents of a named Ethernet services access list. For example, you can verify the output to see that the destination access list list-2 contains all the information from the source access list list-1.

Resequencing Access-List Entries

This task shows how to reassign sequence numbers to entries in a named access list. Resequencing an access list is optional.

SUMMARY STEPS

1. **resequence access-list ethernet-service** *access-list-name* [*starting-sequence-number* [*increment*]]
2. **end**
   or
   commit
3. **show access-lists ethernet-services** [*access-list-name* | **maximum** | **standby** | **summary**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**resequence access-list ethernet-service** *access-list-name* [*starting-sequence-number* [*increment*]] **Example:** `RP/0/RSP0/CPU0:router# resequence access-list ethernet-service L2ACL2 20 10`	(Optional) Resequences the specified Ethernet services access list using the desired starting sequence number and the increment of sequence numbers. • This example resequences an Ethernet services access list named L2ACL2. The starting sequence number is 20 and the increment is 10. If you do not select an increment, the default increment 10 is used. **Note** If during the resequencing process it is determined that the ending number will exceed the maximum sequence number allowed, the configuration will not take effect and will be rejected. The sequence numbers will not be changed.
Step 2	**end** or **commit** **Example:** `RP/0/RSP0/CPU0:router# end` or `RP/0/RSP0/CPU0:router# commit`	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. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 3	**show access-lists ethernet-services** [*access-list-name* | **maximum** | **standby** | **summary**] **Example:** `RP/0/RSP0/CPU0:router# show access-lists ethernet-services L2ACL2`	(Optional) Displays the contents of a named Ethernet services access list. • Review the output to see that the access list includes the updated information.

Configuration Examples for Implementing Layer 2 Access Lists

This section provides these configuration examples:

Resequencing Entries in an Access List: Example

This example shows access-list resequencing. The starting value in the resequenced access list is 1, and the increment value is 2. The subsequent entries are ordered based on the increment values that users provide, and the range is from 1 to 2147483646.

When an entry with no sequence number is entered, by default, it has a sequence number of 10 more than the last entry in the access list.

```
ethernet service access-list acl_1
10 permit 1.2.3 4.5.6
20 deny 2.3.4 5.4.3
30 permit 3.1.2 5.3.4 cos 5

resequence access-list ethernet service acl_1 10 20

show access-list ethernet-service acl1_1

ipv4 access-list acl_1
  10 permit 1.2.3 4.5.6
  30 deny 2.3.4 5.4.3
  50 permit 3.1.2 5.3.4 cos 5
```

Adding Entries with Sequence Numbers: Example

In this example, a new entry is added to Ethernet services access list acl_5.

```
ethernet-service access-list acl_5
2 permit 1.2.3 5.4.3
5 permit 2.3.4. 6.5.4 cos 3
10 permit any dei
20 permit 6.5.4 1.3.5 VLAN vlan3

configure
    ethernet-service access-list acl_5
    15 permit 1.5.7 7.5.1
    end

ethernet-service access-list acl_5
2 permit 1.2.3 5.4.3
5 permit 2.3.4. 6.5.4 cos 3
10 permit any dei
15 permit 1.5.7 7.5.1
20 permit 6.5.4 1.3.5 VLAN vlan3
```

Additional References

These sections provide references related to implementing Ethernet services access lists on Cisco ASR 9000 Series Routers.

Related Documents

Related Topic	Document Title
Ethernet services access list commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples	*Ethernet Services (Layer 2) Access List Commands on Cisco ASR 9000 Series Routers* module in *Cisco ASR 9000 Series Aggregation Services Router IP Addresses and Services Command Reference*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
—	To locate and download MIBs using Cisco IOS XR software, use the Cisco MIB Locator found at this URL and choose a platform under the Cisco Access Products menu: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport

System Considerations

This module provides information on the Cisco ASR 9000 Series Routers scale limitations.

Note The **show l2vpn capability** command displays the scale limitation for the router.

Scale Limitations

Table 4 provides information on the Scale limitations for the Cisco ASR 9000 Series Routers.

Note The limitations in Table 4 are specified on a per VFI basis.

Table 4 Scale Limitations

	Port/Bundle	Line Card			Bridge Domain			System
		L	B	E	L	B	E	
Subinterfaces	NA	32K	64K	64K	4K	8K	8K	64K
Bridge Domains	NA	NA	NA	NA	NA	NA	NA	8K
Pseudowires	NA	NA	NA	NA	NA	NA	NA	64K
LAG Bundles	NA	NA	NA	40	NA	NA	NA	128
LAG Subinterfaces	4K	8K	8K	8K	NA	NA	NA	16K
Learned MACs	512K	512K	512K	512K	512K	512K	512K	512K

K = 1024

Line cards:

L—Low Queue Line card, for example: A9K-40GE-L

B—Base Line card, for example: A9K-40GE-B

E—Extended Line card, for example: A9K-40GE-E

Note To achieve the scale values, subinterfaces must be evenly allocated between the line card's physical ports.

For more information on Ethernet line cards, see *Table 1-3* of the *Cisco ASR 9000 Series Aggregation Services Router Ethernet Line Card Installation Guide*.

Additional References

These sections provide references related to implementing Ethernet services access lists on Cisco ASR 9000 Series Routers.

Related Documents

Related Topic	Document Title
Ethernet services access list commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples	*Ethernet Services (Layer 2) Access List Commands on Cisco ASR 9000 Series Routers* module in *Cisco ASR 9000 Series Aggregation Services Router IP Addresses and Services Command Reference*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
—	To locate and download MIBs using Cisco IOS XR software, use the Cisco MIB Locator found at this URL and choose a platform under the Cisco Access Products menu: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport

INDEX

AR	Cisco ASR 9000 Series Aggregation Services Router Advanced System Command Reference
HR	Cisco ASR 9000 Series Aggregation Services Router Interface and Hardware Component Command Reference
IR	Cisco ASR 9000 Series Aggregation Services Router IP Addresses and Services Command Reference
MCR	Cisco ASR 9000 Series Aggregation Services Router Multicast Command Reference
MNR	Cisco ASR 9000 Series Aggregation Services Router System Monitoring Command Reference
MPR	Cisco ASR 9000 Series Aggregation Services Router MPLS Command Reference
QR	Cisco ASR 9000 Series Aggregation Services Router Modular Quality of Service Command Reference
RR	Cisco ASR 9000 Series Aggregation Services Router Routing Command Reference
SMR	Cisco ASR 9000 Series Aggregation Services Router System Management Command Reference
SR	Cisco ASR 9000 Series Aggregation Services Router System Security Command Reference
LSR	Cisco ASR 9000 Series Aggregation Services Router L2VPN and Ethernet Services Command Reference

A

B

D

E

F

G

I

L

M

N

P

Q

R

S

T

V

W