L2VPN Interworking

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Interworking is a transforming function that is required to interconnect two heterogeneous attachment circuits (ACs). Several types of interworking functions exist. The function that is used would depend on the type of ACs being used, the type of data being carried, and the level of functionality required. The two main Layer 2 Virtual Private Network (L2VPN) interworking functions supported in Cisco IOS XE software are bridged and routed interworking.

Layer 2 (L2) transport over multiprotocol label switching (MPLS) and IP already exists for like-to-like ACs, such as Ethernet-to-Ethernet or Point-to-Point Protocol (PPP)-to-PPP. L2VPN Interworking builds on this functionality by allowing disparate ACs to be connected. An interworking function facilitates the translation between different L2 encapsulations.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the "Feature Information for L2VPN Interworking" section on page 43.

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

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Prerequisites for L2VPN Interworking

Before you configure L2VPN interworking on a router you must enable Cisco Express Forwarding.

Restrictions for L2VPN Interworking

The following sections list the L2VPN Interworking restrictions:

General Restrictions for L2VPN Interworking

This section lists general restrictions that apply to L2VPN interworking. Other restrictions that are platform-specific or device-specific are listed in the following sections.

- MTU configured on the AC should not exceed the MTU in the core of the network because fragmentation is not supported.
- The interworking type on one provider edge (PE) router must match the interworking type on the peer PE router.
- IP Interworking with native VLANs is not supported.
- Only the following quality of service (QoS) features are supported with L2VPN interworking:
  - Static IP type of service (ToS) or MPLS experimental bit (EXP) setting in tunnel header
  - One-to-one mapping of VLAN priority bits to MPLS EXP bits

Routed Interworking Restrictions

Routed interworking has the following restrictions:

- Multipoint Frame Relay (FR) is not supported.
- QoS classification on IP ToS, DSCP and other IP header fields is not supported.
- Security access control list (ACL) and other features based on IP header fields parsing are not supported.
- In routed mode, only one customer edge (CE) router can be attached to an Ethernet PE router.
- There must be a one-to-one relationship between an AC and the pseudowire. Point-to-multipoint or multipoint-to-point configurations are not supported.
- You must configure routing protocols for point-to-point operation on the CE routers when configuring an Ethernet to non-Ethernet setup.

- In the IP interworking mode, the IPv4 (0800) translation is supported. The PE router captures Address Resolution Protocol (ARP) (0806) packets and responds with its own MAC address (proxy ARP). Everything else is dropped.
- The Ethernet must contain only two IP devices: PE router and CE router. The PE router performs proxy ARP and responds to all ARP requests it receives. Therefore, only one CE router and one PE router should be on the Ethernet segment.
- If the CE routers are doing static routing, you can perform the following tasks:
  - The PE router needs to learn the MAC address of the CE router to correctly forward traffic to it. The Ethernet PE router sends an Internet Control Message Protocol (ICMP) Router Discovery Protocol (RDP) solicitation message with the source IP address as zero. The Ethernet CE router responds to this solicitation message. To configure the Cisco CE router's Ethernet interface to respond to the ICMP RDP solicitation message, issue the **ip irdp** command in interface configuration mode. If you do not configure the CE router, traffic is dropped until the CE router sends traffic toward the PE router.
  - To disable the CE routers from running the router discovery protocol, issue the **ip irdp maxadvertinterval 0** command in interface configuration mode.
- When you change the interworking configuration on an Ethernet PE router, clear the ARP entry on the adjacent CE router so that it can learn the new MAC address. Otherwise, you might experience traffic drops.

PPP Interworking Restrictions

The following restrictions apply to PPP interworking:

- There must be a one-to-one relationship between a PPP session and the pseudowire. Multiplexing of multiple PPP sessions over the pseudowire is not supported.
- Only IP (IPv4 (0021) interworking is supported. Link Control Protocol (LCP) packets and Internet Protocol Control Protocol (IPCP) packets are terminated at the PE router. Everything else is dropped.
- By default, the PE router assumes that the CE router knows the remote CE router's IP address.
- Password Authentication Protocol (PAP) and Challenge-Handshake Authentication Protocol (CHAP) authentication are supported.

Ethernet/VLAN-to-ATM AAL5 Interworking Restrictions

The Ethernet/VLAN to ATM AAL5 Any Transport over MPLS (AToM) has the following restrictions:

- Only the following translations are supported; other translations are dropped:
  - Ethernet without LAN FCS (AAAA030080C200070000)
  - Spanning tree (AAAA030080C2000E)
- The ATM encapsulation type supported for bridged interworking is aal5snap. However, ATM encapsulation types supported for routed interworking are aal5snap and aal5mux.
- The existing QoS functionality for ATM is supported, including setting the ATM CLP bit.
- Only ATM AAL5 VC mode is supported. ATM VP and port mode are not supported.
- SVCs are not supported.

- Individual AAL5 ATM cells are assembled into frames before being sent across the pseudowire.
- Non-AAL5 traffic, (such as Operation, Administration, and Maintenance (OAM) cells) is punted to be processed at the route processor (RP) level. A VC that has been configured with OAM cell emulation on the ATM PE router (using the **oam-ac emulation-enable** CLI command) can send end-to-end F5 loopback cells at configured intervals toward the CE router.
- When the pseudowire is down, an F5 end-to-end segment alarm indication signal/remote defect indication (AIS/RDI) is sent from the PE router to the CE router.
- If the Ethernet frame arriving from the Ethernet CE router includes a 802.1Q header (VLAN header), due to the type of endpoint attachment (Ethernet port mode), the VLAN header stays in the frame across the pseudowire (Figure 1).

Figure 1 Protocol Stack for ATM-to-Ethernet AToM Bridged Interworking—with VLAN Header

Ethernet/VLAN-to-Frame Relay Interworking Restrictions

The Ethernet/VLAN-to-Frame Relay AToM has the following restrictions:

- Only the following translations are supported; other translations are dropped:
  - Ethernet without LAN FCS (0300800080C20007)
  - Spanning tree (0300800080C2000E)
- The PE router automatically supports translation of both Cisco and IETF Frame Relay encapsulation types coming from the CE router, but translates only to IETF when sending to the CE router. This is not a problem for the Cisco CE router, because it can manage IETF encapsulation upon receipt even if it is configured to send a Cisco encapsulation.
- The PVC status signaling works the same way as in the like-to-like case. The PE router reports the PVC status to the CE router based upon the availability of the pseudowire.
- The AC maximum transmission unit (MTU) must be within the supported range of MTUs when connected over MPLS.
- Only Frame Relay DLCI mode is supported. Frame Relay port mode is not supported.

- If the Ethernet frame includes a 802.1Q header (VLAN header), due to the type of endpoint attachment (Ethernet port mode), the VLAN header stays in the frame across the pseudowire (Figure 2).
- Frame Relay encapsulation types supported for routed interworking are Cisco and IETF for incoming traffic. However, IETF is also supported for outgoing traffic traveling to the CE router.

Figure 2 Protocol Stack for Frame Relay-to-Ethernet AToM Bridged Interworking—with VLAN Header

Information About L2VPN Interworking

The following sections provide an introduction to L2VPN interworking.

Overview of L2VPN Interworking

L2 transport over MPLS and IP already exists for like-to-like ACs, such as Ethernet-to-Ethernet or PPP-to-PPP. L2VPN Interworking builds on this functionality by allowing disparate ACs to be connected. An interworking function facilitates the translation between the different L2 encapsulations.

Only the following interworking combinations are supported in Cisco IOS XE Release 3.3S:

- ATM-to-Ethernet – Routed interworking
- ATM-to-Ethernet – Bridged interworking
- Frame relay-to-Ethernet – Bridged interworking

- PPP-to-Ethernet – IP interworking

L2VPN Interworking Modes

L2VPN interworking works in either Ethernet (bridged) mode or IP (routed) mode. You specify the mode by issuing the **interworking** {**ethernet** | **ip**} command in pseudowire-class configuration mode.

The **interworking** command causes the ACs to be terminated locally. The two keywords perform the following functions:

- The **ethernet** keyword causes Ethernet frames to be extracted from the AC and sent over the pseudowire. Ethernet end-to-end transmission is resumed. AC frames that are not Ethernet are dropped. In the case of VLAN, the VLAN tag is removed, leaving an untagged Ethernet frame.
- The **ip** keyword causes IP packets to be extracted from the AC and sent over the pseudowire. AC frames that do not contain IPv4 packets are dropped.

The following sections explain more about Ethernet and IP interworking modes.

Ethernet or Bridged Interworking

Ethernet interworking is also called bridged interworking. Ethernet frames are bridged across the pseudowire. The CE routers could be natively bridging Ethernet or could be routing using a bridged encapsulation model, such as Bridge Virtual Interface (BVI) or Routed Bridge Encapsulation (RBE). The PE routers operate in Ethernet like-to-like mode.

This mode is used to offer the following services:

- LAN services—An example is an enterprise that has several sites, where some sites have Ethernet connectivity to the service provider (SP) network and others have ATM connectivity. If the enterprise wants LAN connectivity to all its sites, traffic from the Ethernet or VLAN of one site can be sent through the IP/MPLS network and encapsulated as bridged traffic over an ATM VC of another site.
- Connectivity services—An example is an enterprise that has different sites that are running an Internal Gateway Protocol (IGP) routing protocol, which has incompatible procedures on broadcast and nonbroadcast links. The enterprise has several sites that are running an IGP, such as Open Shortest Path First (OSPF) or Intermediate System-to-Intermediate System (IS-IS), between the sites. In this scenario, some of the procedures (such as route advertisement or designated router) depend on the underlying L2 protocol and are different for a point-to-point ATM connection versus a broadcast Ethernet connection. Therefore, the bridged encapsulation over ATM can be used to achieve homogenous Ethernet connectivity between the CE routers running the IGP.

IP or Routed Interworking

IP interworking is also called routed interworking. The CE routers encapsulate the IP on the link between the CE router and PE router. A new VC type is used to signal the IP pseudowire in MPLS. Translation between the L2 and IP encapsulations across the pseudowire is required. Special consideration needs to be given to the address resolution and routing protocol operation, because these are handled differently on different L2 encapsulations.

This mode is used to provide IP connectivity between sites, regardless of the L2 connectivity to these sites. It is different from a Layer 3 VPN because it is point-to-point in nature and the service provider does not maintain any customer routing information.

Address resolution is encapsulation dependent:

- Ethernet uses ARP
- ATM uses inverse ARP
- PPP uses IPCP

Therefore, address resolution must be terminated on the PE router. End-to-end address resolution is not supported. Routing protocols operate differently over broadcast and point-to-point media. For Ethernet, the CE routers must either use static routing or configure the routing protocols to treat the Ethernet side as a point-to-point network.

In routed interworking, IP packets that are extracted from the ACs are sent over the pseudowire. The pseudowire works in the IP Layer 2 transport (VC type 0x000B) like-to-like mode. The interworking function at network service provider's (NSP) end performs the required adaptation based on the AC technology. Non-IPv4 packets are dropped.

In routed interworking, the following considerations are to be kept in mind:

- Address resolution packets (ARP), inverse ARP, and IPCP are punted to the routing protocol. Therefore, NSP at the PE router must provide the following functionality for address resolution:
  - Ethernet—PE device acts as a proxy-ARP server to all ARP requests from the CE router. The PE router responds with the MAC address of its local interface.
  - ATM and Frame Relay point-to-point—By default, inverse ARP does not run in the point-to-point Frame Relay or ATM subinterfaces. The IP address and subnet mask define the connected prefix; therefore, configuration is not required in the CE devices.
- Interworking requires that the MTUs in both ACs match for the pseudowire to come up. The default MTU in one AC should match with the MTU of other AC. Table 1 lists the range of MTUs that can be configured for different ACs.

Table 1 Range of MTUs for Different ACs

AC type	Range of MTUs supported
ATM	64 to 17940
Gigabit Ethernet	1500 to 4470
POS	64to 9102
Fast Ethernet	64to 9192

Note The MTU configured on the AC should not exceed the MTU in the core network. This ensures that the traffic is not fragmented.

- The CE routers with Ethernet attachment VCs running OSPF must be configured with the **ospfIfType** option so that the OSPF protocol treats the underlying physical broadcast link as a P2P link.

Ethernet/VLAN-to-ATM AAL5 Interworking

The following topics are covered in this section:

- ATM AAL5-to-Ethernet Port AToM—Bridged Interworking, page 8

ATM AAL5-to-Ethernet Port AToM—Bridged Interworking

This interworking type provides interoperability between the ATM attachment VC and Ethernet attachment VC connected to different PE routers. Bridged encapsulation corresponding to the bridged (Ethernet) interworking mechanism is used.

The interworking function is performed at the PE router connected to the ATM attachment VC based on multiprotocol encapsulation over ATM AAL5 (Figure 3).

Figure 3 Network Topology for ATM-to-Ethernet AToM Bridged Interworking

The advantage of this architecture is that the Ethernet PE router (connected to the Ethernet segment) operates similarly to Ethernet like-to-like services.

On the PE router with interworking function, in the direction from the ATM segment to MPLS cloud, the bridged encapsulation (ATM/subnetwork access protocol (SNAP) header) is discarded and the Ethernet frame is encapsulated with the labels required to go through the pseudowire using the VC type 5 (Ethernet) (Figure 4).

In the opposite direction, after the label disposition from the MPLS cloud, Ethernet frames are encapsulated over AAL5 using bridged encapsulation.

Figure 4 shows the protocol stack for ATM-to-Ethernet AToM bridged interworking. The ATM side has an encapsulation type of aal5snap.

Figure 4 Protocol Stack for ATM-to-Ethernet AToM Bridged Interworking—without VLAN Header

ATM AAL5-to-Ethernet VLAN 802.1Q AToM—Bridged Interworking

This interworking type provides interoperability between the ATM attachment VC and Ethernet VLAN attachment VC connected to different PE routers. Bridged encapsulation corresponding to the bridged (Ethernet) interworking mechanism is used.

The interworking function is performed in the same way as for the ATM-to-Ethernet port case, implemented on the PE router connected to the ATM attachment VC. The implementation is based on multiprotocol encapsulation over ATM AAL5 (see Figure 3).

For the PE router connected to the Ethernet side, one major difference exists due the existence of the VLAN header in the incoming packet. The PE router discards the VLAN header of the incoming frames from the VLAN CE router, and the PE router inserts a VLAN header into the Ethernet frames traveling from the MPLS cloud. The frames sent on the pseudowire (with VC type 5) are Ethernet frames without the VLAN header.

Encapsulation over ATM AAL5 is shown in Figure 5.

Figure 5 Protocol Stack for ATM -to-VLAN AToM Bridged Interworking

ATM-to-Ethernet—Routed Interworking

To perform routed interworking, both the ATM PE router and Ethernet PE router must be configured. Figure 6 shows the routed interworking between ATM to Ethernet. The IP encapsulation over the pseudowire is performed on the ATM packets arriving from the ATM CE router.

The address resolution is done at the ATM PE router; it is required when the ATM CE router does an inverse ARP. It is not required when the ATM CE router is configured using Point-to-Point (P2P) subinterfaces or static maps.

When packets arrive from the Ethernet CE router, the Ethernet PE router removes the L2 frame tag, and then forwards the IP packet to the egress PE router, using IPoMPLS encapsulation over the pseudowire. The Ethernet PE router makes the forwarding decision based on the L2 circuit ID, the VLAN ID, or port ID, of the incoming L2 frame. At the ATM PE router, after label disposition, the IP packets are encapsulated over the AAL5 using routed encapsulation based on RFC 2684.

The address resolution at the Ethernet PE router can be done when the Ethernet CE router configures the static ARP, or by the proxy ARP on the Ethernet PE router. If the proxy ARP is used, the IP address of the remote CE router can be learned dynamically.

Routing protocols need to be configured to operate in the P2P mode on the Ethernet CE router.

Figure 6 Protocol Stack for ATM-to-Ethernet—Routed Interworking

Ethernet/VLAN-to-Frame Relay Interworking

The following topics are covered in this section:

Frame Relay DLCI-to-Ethernet Port AToM—Bridged Interworking

This interworking type provides interoperability between the Frame Relay attachment VC and Ethernet attachment VC connected to different PE routers. Bridged encapsulation corresponding to the bridged (Ethernet) interworking mechanism is used.

For an FR-to-Ethernet port case, the interworking function is performed at the PE router connected to the FR attachment VC based on multiprotocol interconnect over Frame Relay (Figure 7). The interworking is implemented similar to an ATM-to-Ethernet case.

Figure 7 Network Topology for FR-to-Ethernet AToM Bridged Interworking

The advantage of this architecture is that the Ethernet PE router (connected to the Ethernet segment) operates similar to Ethernet like-to-like services: a pseudowire label is assigned to the Ethernet port and then the remote Label Distribution Protocol (LDP) session distributes the labels to its peer PE router. Ethernet frames are carried through the MPLS network using Ethernet over MPLS (EoMPLS).

On the PE router with interworking function, in the direction from the Frame Relay segment to the MPLS cloud, the bridged encapsulation (FR/SNAP header) is discarded and the Ethernet frame is encapsulated with the labels required to go through the pseudowire using the VC type 5 (Ethernet) (Figure 8).

In the opposite direction, after the label disposition from the MPLS cloud, Ethernet frames are encapsulated over Frame Relay using bridged encapsulation.

The following translations are supported:

- Ethernet without LAN FCS (0300800080C20007)
- Spanning tree (0300800080C2000E)

The PE router automatically supports translation of both Cisco and IETF Frame Relay encapsulation types coming from the CE, but translates only to IETF when sending to the CE router. This is not a problem for the Cisco CE router, because it can handle IETF encapsulation on receipt even if it is configured to send Cisco encapsulation.

The existing QoS functionality for Frame Relay is supported. The PVC status signaling works the same way as in the like-to-like case. The PE router reports the PVC status to the CE router, based on the availability of the pseudo wire.

The AC MTU must match when connected over MPLS. Only Frame Relay DLCI mode is supported; Frame Relay port mode is not supported in the bridged interworking.

The Figure 8 shows the protocol stack for FR-to-Ethernet bridged interworking.

Figure 8 Protocol Stack for FR-to-Ethernet AToM Bridged Interworking—without VLAN Header

Frame Relay DLCI-to-Ethernet VLAN 802.1Q AToM—Bridged Interworking

This interworking type provides interoperability between the Frame Relay attachment VC and Ethernet VLAN Attachment VC connected to different PE routers. The bridged encapsulation corresponding to the bridged (Ethernet) interworking mechanism is used.

The interworking function is performed in the same way as it is done for the Frame Relay to Ethernet port case; it is implemented on the PE router connected to the Frame Relay attachment VC, based upon a multiprotocol interconnect over Frame Relay (see Figure 8).

As in the ATM-to-VLAN case, one difference exists on the Ethernet side due the existence of the VLAN header in the incoming packet. The PE router on the VLAN side discards the VLAN header of the incoming frames from the VLAN CE router, and the PE router inserts a VLAN header into the Ethernet frames traveling from the MPLS cloud. The frames sent on the pseudowire (with VC type 5) are Ethernet frames without the VLAN header.

The Figure 9 shows the protocol stack for FR-to-VLAN AToM bridged interworking.

Figure 9 Protocol Stack for FR-to-VLAN AToM Bridged Interworking

Frame Relay DLCI-to-Ethernet VLAN Qot1Q/QinQ AToM – Bridged Interworking

This interworking type provides interoperability between the Frame Relay Attachment VC and Ethernet VLAN Attachment VC connected to different PE routers. The bridged encapsulation corresponding to bridged (Ethernet) interworking mechanism is used.

The interworking function is done in the same way as it is done for FR-to-Ethernet port case; it is implemented on the PE router connected to the Frame Relay attachment VC, based on RFC 2427(Multiprotocol Interconnect over Frame Relay).

When compared with Frame Relay DLCI-to-Ethernet port AToM, there is one major difference on the Ethernet access side, due the existence of the VLAN header in the incoming packet. The PE router on the VLAN side will discard the VLAN header of the incoming frames form the VLAN CE router, and it will insert a VLAN header into the Ethernet frames coming from the MPLS cloud. So the frames sent on the pseudo wire (with VC type 5) will be Ethernet frames without the VLAN header.

The following translations are supported on the Frame Relay PE router:

- Ethernet without LAN FCS (0300800080C20007)
- Spanning tree (0300800080C2000E)

Frame Relay encapsulation types supported for bridged interworking: Cisco and IETF for incoming traffic, IETF only for outgoing traffic towards CE router.

ATM Local Switching

- ATM like-to-like local switching allows switching data between two physical interfaces where both the segments are of ATM type. The two interfaces must be on the same PE router. Table 2 lists the supported ATM local switching combinations.

Table 2 ATM local switching - supported combinations

	Same port Point-to-Point	Different port Point-to-Point	Same Port Multipoint	Different Port Multipoint
Port Mode	No	No	No	No
VC-to-VC AAL0	Yes	Yes	Yes	Yes
VC-to-VC AAL5	Yes	Yes	Yes	Yes
VP-to-VP AAL0	No	No	Yes	Yes
VP-to-VP AAL5	No	No	No	No

The following topics are covered in this section:

- VC-to-VC Local Switching, page 15
- VP-to-VP Local Switching, page 15

VC-to-VC Local Switching

VC-to-VC local switching transports cells between two ATM attachment VCs on the same or different port on the PE router. The cells coming to the PE router can be AAL0 or AAL5 encapsulated ATM packets. ATM VC-to-VC local switching can be configured either on point-to-point interface or on multipoint interface.

There are two operation modes for managing OAM cells over ATM local switching interfaces:

- OAM transparent mode: In this mode, the PE router transports F5 OAM cells transparently across local switching interfaces.
- OAM local emulation mode: In this mode, the PE router does not transport OAM cells across local switching interfaces. Instead, the interfaces locally terminate and process F5 OAM cells.

In ATM single cell relay AAL0, the ATM virtual path identifier/virtual channel identifier (VPI/VCI) values of the ingress and egress ATM interfaces of a router must match. If L2 local switching is desired between two ATM VPIs and VCIs, which are on two different interfaces and have values that do not match, ATM AAL5 should be selected. However, if ATM AAL5 uses OAM transparent mode, the VPI and VCI values must match.

ATM OAM can be configured on ATM VC mode local switching AC using the **oam-ac emulation-enable** and **oam-pvc manage** commands. When emulation is enabled on the AC, all OAM cells going through the AC are punted to RP for local processing. The ATM common component processes OAM cells and forwards the cells towards the local CE router. This helps to detect the failures on the PE router by monitoring the response at the CE router end. When the **oam-pvc manage** command is enabled on the AC, the PVC generates end-to-end OAM loopback cells that verify connectivity on the VC.

The following example shows a sample configuration on the ATM PE router:

```
configure terminal
interface atm 4/0.50 multipoint
    no ip address
    no atm enable-ilmi-trap
pvc 100/100 l2transport
    encapsulation aal5
    oam-ac emulation-enable
    oam-pvc manage
interface atm 5/0.100 multipoint
    no ip address
    no atm enable-ilmi-trap
    pvc 100/100 l2transport
        encapsulation aal5
        oam-ac emulation-enable
        oam-pvc manage

connect atm_ls atm 4/0 100/100 atm 5/0 100/100
```

VP-to-VP Local Switching

VP-to-VP local switching transports cells between two VPs on the same port or different ports on the PE router. The cells coming to the PE router can be AAL0 encapsulated ATM packets only. ATM VP-to-VP local switching can be configured only on multipoint interfaces.

There are two operation modes for managing OAM cells over ATM local switching interfaces:

- OAM transparent mode: In this mode, the PE router transports F4 OAM cells transparently across local switching interfaces.

- OAM local emulation mode: In this mode, the PE router do not transport OAM cells across local switching interfaces. Instead, the interfaces locally terminate and process F4 OAM cells.

In ATM single cell relay AAL0, the ATM VPI values of the ingress and egress ATM interfaces on a router must match. If L2 switching is desired between two ATM VPIs which are on two different interfaces and have values that do not match, ATM AAL5 should be selected. If ATM AAL5 uses OAM transparent mode, the VPI value must match. Currently, the ATM VP-to-VP local switching supports only AAL0 encapsulation.

ATM OAM can be configured on the ATM VP mode local switching AC using the **oam-ac emulation-enable** command. When emulation is enabled on the AC, all OAM cells going through the AC are punted to RP for local processing. The ATM common component processes the OAM cells and forwards the cells towards the local CE router. This helps to detect failures on the PE router by monitoring the response at the CE router's end.

The following example shows a sample configuration on the ATM PE router:

```
configure terminal
interface atm 4/0.100 multipoint
    no ip address
    no atm enable-ilmi-trap
atm pvp 100 l2transport
    encapsulation aal5
    oam-ac emulation-enable
interface atm 5/0.100 multipoint
    no ip address
    no atm enable-ilmi-trap
    atm pvp 100 l2transport
        encapsulation aal5
        oam-ac emulation-enable
connect atm_ls atm 4/0 100 atm 5/0 100
```

PPP-to-Ethernet AToM–Routed Interworking

In this interworking type, one of the ACs is Ethernet and the other is PPP. Each link is terminated locally on the corresponding PE routers and the extracted layer 3 (L3) packets are transported over a pseudowire.

The PE routers connected to Ethernet and PPP ACs terminate their respective L2 protocols. The PPP session is terminated for both the LCP and the Network Control Protocol (NCP) layers. On the ingress PE router, after extracting L3 packets, each PE router forwards the packets over the already established pseudowire using MPoMPLS encapsulation. On the egress PE router, after performing label disposition, the packets are encapsulated based on the corresponding link layer and are sent to the respective CE router. This interworking scenario requires the support of MPoMPLS encapsulation by the PE routers.

In PPP-to-Ethernet AToM routed interworking mode IPCP is supported. Proxy IPCP is automatically enabled on the PE router when IP interworking is configured on the pseudowire. By default, the PE router gets the IP address it needs to use from the CE router. The PE router accomplishes this by sending an IPCP confreq with the IP address 0.0.0.0. The local CE router has the remote CE router's IP address configured on it. The following example shows a sample configuration on the PPP CE router:

```
interface serial2/0
 ip address 168.65.32.13 255.255.255.0
 encapsulation ppp
peer default ip address 168.65.32.14  *
```

If the remote CE router's IP address cannot be configured on the local CE router, then the remote CE router's IP address can be configured on the PE router using the **ppp ipcp address proxy** *ip address* command on the xconnect PPP interface of PE router. The following example shows a sample configuration on the PPP PE router:

```
pseudowire-class mp
 encapsulation mpls
 protocol ldp
 interworking ip
!
int se2/0
 encap ppp
 xconnect 10.0.0.2 200 pw-class mp
 ppp ipcp address proxy 168.65.32.14
```

Static IP Addresses for L2VPN Interworking for PPP

If the PE router needs to perform address resolution with the local CE router for PPP, configure the remote CE router's IP address on the PE router. Use the **ppp ipcp address proxy** command with the remote CE router's IP address on the PE router's xconnect PPP interface. The following example shows a sample configuration:

```
pseudowire-class ip-interworking
 encapsulation mpls
 interworking ip

interface Serial2/0
 encapsulation ppp
 xconnect 10.0.0.2 200 pw-class ip-interworking
 ppp ipcp address proxy 10.65.32.14
```

You can also configure the remote CE router's IP address on the local CE router with the **peer default ip address** command if the local CE router performs address resolution.

How to Configure L2VPN Interworking

This section describes how to configure the following L2VPN interworking features:

- Configuring L2VPN Interworking, page 17
- Configuring Ethernet/VLAN-to-ATM AAL5 Interworking, page 19
- Configuring Ethernet/VLAN-to-Frame Relay Interworking, page 27

Configuring L2VPN Interworking

L2VPN interworking allows you to connect disparate ACs. Configuring L2VPN interworking feature requires that you add the **interworking** command to the list of commands that make up the pseudowire. The steps for configuring the pseudowire for L2VPN interworking are included in this section. You use the **interworking** command as part of the overall AToM configuration. For specific instructions on configuring AToM, see the *Any Transport over MPLS* document.

SUMMARY STEPS

1. **enable**

2. **configure terminal**
3. **pseudowire-class** *name*
4. **encapsulation** {**mpls** | **l2tpv3**}
5. **interworking** {**ethernet** | **ip** | **vlan**}
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**pseudowire-class** *name* **Example:** `Router(config)# pseudowire-class class1`	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
Step 4	**encapsulation** {**mpls** | **l2tpv3**} **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation, which is either **mpls** or **l2tpv3**.
Step 5	**interworking** {**ethernet** | **ip** | **vlan**} **Example:** `Router(config-pw)# interworking ip`	Specifies the type of pseudowire and the type of traffic that can flow across it.
Step 6	**end** **Example:** `Router(config-pw)# end`	Exits pseudowire class configuration mode and returns to privileged EXEC mode.

Verifying the L2VPN Configuration

You can verify L2VPN configuration using the following steps:

- You can issue the **show arp** command between the CE routers to ensure that data is being sent:

```
Router# show arp

Protocol   Address       Age (min)   Hardware Addr    Type    Interface
Internet   10.1.1.5          134    0005.0032.0854   ARPA    FastEthernet0/0/0
Internet   10.1.1.7            -    0005.0032.0000   ARPA    FastEthernet0/0/0
```

- You can issue the **ping** command between the CE routers to ensure that data is being sent:

```
Router# ping 10.1.1.5
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.5, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
```

- You can verify the AToM configuration by using the **show mpls l2transport vc detail** command.

Configuring Ethernet/VLAN-to-ATM AAL5 Interworking

This section explains the following AToM configurations:

- ATM AAL5-to-Ethernet Port, page 19
- ATM AAL5-to-Ethernet Port on a PE2 Router, page 21
- ATM AAL5-to-Ethernet VLAN 802.1Q on a PE1 Router, page 23
- ATM AAL5-to-Ethernet VLAN 802.1Q on a PE2 router, page 25

ATM AAL5-to-Ethernet Port

You can configure the ATM AAL5-to-Ethernet Port feature on a PE1 router using the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls label protocol ldp**
4. **interface** *type number*
5. **ip address** *ip-address mask*
6. **pseudowire-class** [*pw-class-name*]
7. **encapsulation mpls**
8. **interworking** {**ethernet** | **ip** | **vlan**}
9. **interface atm** *slot/subslot/port.subinterface number*
10. **pvc** [*name*] *vpi/vci* **12transport**
11. **encapsulation aal5snap**
12. **xconnect** *ip-address vc-id* **pw-class** *pw-class-name*

13. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mpls label protocol ldp** **Example:** `Router(config)# mpls label protocol ldp`	Establishes the label distribution protocol for the platform.
Step 4	**interface** *type number* **Example:** `Router(config)# interface loopback 100`	Configure an interface type and enters interface configuration mode.
Step 5	**ip address** *ip-address mask* **Example:** `Router(config-if)# ip address 10.0.0.100 255.255.255.255`	Sets the primary or secondary IP address for an interface.
Step 6	**pseudowire-class** [*pw-class-name*] **Example:** `Router(config-if)# pseudowire-class atm-eth`	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
Step 7	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation.
Step 8	**interworking** {**ethernet** | **ip** | **vlan**} **Example:** `Router(config-pw)# interworking ip`	Specifies the type of pseudowire and the type of traffic that can flow across it.
Step 9	**interface atm** *slot*/*subslot*/*port*.*subinterface number* **Example:** `Router(config-pw)# interface atm 2/0/0.1`	Configures an ATM interface and enters interface configuration mode.

	Command or Action	Purpose
Step 10	**pvc** [*name*] *vpi*/*vci* **l2transport** **Example:** `Router(config-subif)# pvc 0/200 l2transport`	Assigns a name to an ATM permanent virtual circuit (PVC) and enters ATM virtual circuit configuration mode.
Step 11	**encapsulation aal5snap** **Example:** `Router(config-if-atm-member)# encapsulation aal5snap`	Configures the ATM AAL and encapsulation type for an ATM VC.
Step 12	**xconnect** *ip-address vc-id* **pw-class** *pw-class-name* **Example:** `Router(config-if-atm-member)# xconnect 10.0.0.200 140 pw-class atm-eth`	Binds an AC to a pseudowire and configures an AToM static pseudowire.
Step 13	**end** **Example:** `Router(config-if-xconn)# end`	Exits xconnect configuration mode and returns to privileged EXEC mode.

ATM AAL5-to-Ethernet Port on a PE2 Router

You can configure the ATM AAL5-to-Ethernet Port feature on a PE2 router using the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls label protocol ldp**
4. **interface** *type number*
5. **ip address** *ip-address mask*
6. **pseudowire-class** [*pw-class-name*]
7. **encapsulation mpls**
8. **interworking** {**ethernet** | **ip** | **vlan**}
9. **interface** *type slot/subslot/port*
10. **xconnect** *ip-address vc-id* **pw-class** *pw-class-name*

11. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mpls label protocol ldp** **Example:** `Router(config)# mpls label protocol ldp`	Establishes the label distribution protocol for the platform.
Step 4	**interface** *type number* **Example:** `Router(config)# interface loopback 100`	Configure an interface type and enters interface configuration mode.
Step 5	**ip address** *ip-address mask* **Example:** `Router(config-if)# ip address 10.0.0.100 255.255.255.255`	Sets the primary or secondary IP address for an interface.
Step 6	**pseudowire-class** [*pw-class-name*] **Example:** `Router(config-if)# pseudowire-class atm-eth`	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
Step 7	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation.
Step 8	**interworking** {**ethernet** | **ip** | **vlan**} **Example:** `Router(config-pw)# interworking ip`	Specifies the type of pseudowire and the type of traffic that can flow across it.
Step 9	**interface** *type slot*/*subslot*/*port* **Example:** `Router(config-pw)# interface gigabitethernet 5/1/0`	Configure an interface and enters interface configuration mode.

	Command or Action	Purpose
Step 10	**xconnect** *ip-address vc-id* **pw-class** *pw-class-name* **Example:** `Router(config-if)# xconnect 10.0.0.100 140 pw-class atm-eth`	Binds an AC to a pseudowire and configures an AToM static pseudowire.
Step 11	**end** **Example:** `Router(config-if-xconn)# end`	Exits xconnect configuration mode and returns to privileged EXEC mode.

Note When configuring bridged interworking, the PE2 router configuration does not include the **interworking ethernet** command because it is treated as like-to-like, and also because the AC is already an Ethernet port. However, when configuring routed interworking, the **interworking ip** command is required.

ATM AAL5-to-Ethernet VLAN 802.1Q on a PE1 Router

You can configure the ATM AAL5-to-Ethernet VLAN 802.1Q feature on a PE1 router using the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls label protocol ldp**
4. **interface** *type number*
5. **ip address** *ip-address mask*
6. **pseudowire-class** [*pw-class-name*]
7. **encapsulation mpls**
8. **interworking** {**ethernet** | **ip** | **vlan**}
9. **interface atm** *slot/subslot/port.subinterface-number*
10. **pvc** [*name*] *vpi/vci* **12transport**
11. **encapsulation aal5snap**
12. **xconnect** *ip-address vc-id* **pw-class** *pw-class-name*

13. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mpls label protocol ldp** **Example:** `Router(config)# mpls label protocol ldp`	Establishes the label distribution protocol for the platform.
Step 4	**interface** *type number* **Example:** `Router(config)# interface loopback 100`	Configure an interface type and enters interface configuration mode.
Step 5	**ip address** *ip-address mask* **Example:** `Router(config-if)# ip address 10.0.0.100 255.255.255.255`	Sets the primary or secondary IP address for an interface.
Step 6	**pseudowire-class** [*pw-class-name*] **Example:** `Router(config-if)# pseudowire-class atm-eth`	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
Step 7	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation.
Step 8	**interworking** {**ethernet** | **ip** | **vlan**} **Example:** `Router(config-pw)# interworking ip`	Specifies the type of pseudowire and the type of traffic that can flow across it.
Step 9	**interface atm** *slot*/*subslot*/*port*.*subinterface number* **Example:** `Router(config-pw)# interface atm 2/0/0.1`	Configure an ATM interface and enters interface configuration mode.

	Command or Action	Purpose
Step 10	**pvc** [*name*] *vpi*/*vci* **l2transport** **Example:** `Router(config-subif)# pvc 0/200 l2transport`	Assigns a name to an ATM permanent virtual circuit (PVC) and enters ATM virtual circuit configuration mode.
Step 11	**encapsulation aal5snap** **Example:** `Router(config-if-atm-member)# encapsulation aal5snap`	Configures the ATM AAL and encapsulation type for an ATM VC.
Step 12	**xconnect** *ip-address vc-id* **pw-class** *pw-class-name* **Example:** `Router(config-if-atm-member)# xconnect 10.0.0.200 140 pw-class atm-eth`	Binds an AC to a pseudowire and configures an AToM static pseudowire.
Step 13	**end** **Example:** `Router(config-if-xconn)# end`	Exits xconnect configuration mode and returns to privileged EXEC mode.

ATM AAL5-to-Ethernet VLAN 802.1Q on a PE2 router

You can configure the ATM AAL5-to-Ethernet VLAN 802.1Q feature on a PE2 router using the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls label protocol ldp**
4. **interface** *type number*
5. **ip address** *ip-address mask*
6. **pseudowire-class** [*pw-class-name*]
7. **encapsulation mpls**
8. **interworking** {**ethernet** | **ip** | **vlan**}
9. **interface** *type slot*/*subslot*/*port*.*subinterface-number*
10. **encapsulation dot1q** *vlan-id*
11. **xconnect** *ip-address vc-id* **pw-class** *pw-class-name*

12. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mpls label protocol ldp** **Example:** `Router(config)# mpls label protocol ldp`	Establishes the label distribution protocol for the platform.
Step 4	**interface** *type number* **Example:** `Router(config)# interface loopback 100`	Configure an interface type and enters interface configuration mode.
Step 5	**ip address** *ip-address mask* **Example:** `Router(config-if)# ip address 10.0.0.100 255.255.255.255`	Sets the primary or secondary IP address for an interface.
Step 6	**pseudowire-class** [*pw-class-name*] **Example:** `Router(config-if)# pseudowire-class atm-eth`	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
Step 7	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation.
Step 8	**interworking** {**ethernet** | **ip** | **vlan**} **Example:** `Router(config-pw)# interworking ip`	Specifies the type of pseudowire and the type of traffic that can flow across it.
Step 9	**interface** *type slot*/*subslot*/*port*.*subinterface-number* **Example:** `Router(config-pw)# interface gigabitethernet 5/1/0.3`	Configures an interface and enters interface configuration mode.

	Command or Action	Purpose
Step 10	**encapsulation dot1q** *vlan-id* **Example:** `Router(config-if)# encapsulation dot1q 1525`	Enables IEEE 802.1Q encapsulation of traffic on a specified sub interface in a VLAN.
Step 11	**xconnect** *ip-address vc-id* **pw-class** *pw-class-name* **Example:** `Router(config-if)# xconnect 10.0.0.100 140 pw-class atm-eth`	Binds an AC to a pseudowire and configures an AToM static pseudowire.
Step 12	**end** **Example:** `Router(config-if-xconn)# end`	Exits xconnect configuration mode and returns to privileged EXEC mode.

Note In the case of ATM AAl5-to-VLAN, the PE2 router configuration includes the **interworking** command for both bridged and routed interworking.

Note To verify the L2VPN interworking status and check the statistics, refer to the "Verifying L2VPN Interworking" section on page 35.

Configuring Ethernet/VLAN-to-Frame Relay Interworking

This section explains the following AToM configurations and provides examples. Figure 7 illustrates different AToM configurations.

Frame Relay DLCI-to-Ethernet Port on a PE1 Router

You can configure the Frame Relay DLCI-to-Ethernet Port feature on a PE1 router using the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls label protocol ldp**
4. **interface** *type number*

5. **ip address** *ip-address mask*
6. **pseudowire-class** [*pw-class-name*]
7. **encapsulation mpls**
8. **interworking ethernet**
9. **interface** *type slot/subslot/port*
10. **encapsulation frame-relay**
11. **connect** *connection-name interface dlci* {*interface dlci* | **l2transport**}
12. **xconnect** *ip-address vc-id* **pw-class** *pw-class-name*
13. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mpls label protocol ldp** **Example:** `Router(config)# mpls label protocol ldp`	Establishes the label distribution protocol for the platform.
Step 4	**interface** *type number* **Example:** `Router(config)# interface loopback 100`	Configures an interface type and enters interface configuration mode.
Step 5	**ip address** *ip-address mask* **Example:** `Router(config-if)# ip address 10.0.0.100 255.255.255.255`	Sets the primary or secondary IP address for an interface.
Step 6	**pseudowire-class** [*pw-class-name*] **Example:** `Router(config-if)# pseudowire-class fr-eth`	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
Step 7	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation.

	Command or Action	Purpose
Step 8	**interworking ethernet** **Example:** `Router(config-pw)# interworking ethernet`	Specifies the type of pseudowire and the type of traffic that can flow across it.
Step 9	**interface** *type slot/subslot/port* **Example:** `Router(config-pw)# interface serial 2/0/0`	Configures an interface and enters interface configuration mode.
Step 10	**encapsulation frame-relay** **Example:** `Router(config-if)# encapsulation frame-relay`	Enables Frame Relay encapsulation.
Step 11	**connect** *connection-name interface dlci* {*interface dlci* | **l2transport**} **Example:** `Router(config-if)# connect fr-vlan-1 POS2/3/1 151 l2transport`	Defines the connection between Frame Relay PVCs.
Step 12	**xconnect** *ip-address vc-id* **pw-class** *pw-class-name* **Example:** `Router(config-if)# xconnect 10.0.0.200 151 pw-class pw-class-bridge`	Binds an AC to a pseudowire and configures an AToM static pseudowire.
Step 13	**end** **Example:** `Router(config-if-xconn)# end`	Exits xconnect configuration mode and returns to privileged EXEC mode.

Frame Relay DLCI-to-Ethernet Port on a PE2 router

You can configure the Frame Relay DLCI-to-Ethernet Port feature on a PE2 router using the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls label protocol ldp**
4. **interface** *type number*
5. **ip address** *ip-address mask*
6. **pseudowire-class** [*pw-class-name*]
7. **encapsulation mpls**
8. **interworking ethernet**

9. **interface** *type slot/subslot/port*
10. **xconnect** *ip-address vc-id* **pw-class** *pw-class-name*
11. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mpls label protocol ldp** **Example:** `Router(config)# mpls label protocol ldp`	Establishes the label distribution protocol for the platform.
Step 4	**interface** *type number* **Example:** `Router(config)# interface loopback 100`	Configures an interface type and enters interface configuration mode.
Step 5	**ip address** *ip-address mask* **Example:** `Router(config-if)# ip address 10.0.0.100 255.255.255.255`	Sets the primary or secondary IP address for an interface.
Step 6	**pseudowire-class** [*pw-class-name*] **Example:** `Router(config-if)# pseudowire-class atm-eth`	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
Step 7	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation.
Step 8	**interworking ethernet** **Example:** `Router(config-pw)# interworking ethernet`	Specifies the type of pseudowire and the type of traffic that can flow across it.
Step 9	**interface** *type slot/subslot/port* **Example:** `Router(config-pw)# interface gigabitethernet 2/0/0`	Configures an interface and enters interface configuration mode.

	Command or Action	Purpose
Step 10	**xconnect** *ip-address vc-id* **pw-class** *pw-class-name* **Example:** `Router(config-if)# xconnect 10.0.0.200 140 pw-class atm-eth`	Binds an AC to a pseudowire and configures an AToM static pseudowire.
Step 11	**end** **Example:** `Router(config-if-xconn)# end`	Exits xconnect configuration mode and returns to privileged EXEC mode.

Note When configuring bridged interworking, the PE2 router configuration does not include the **interworking ethernet** command because it is treated as like-to-like, and also because the AC is already an Ethernet port. However, when configuring routed interworking, the PE2 router configuration does include the **interworking ip** command.

Frame Relay DLCI-to-Ethernet VLAN 802.1Q on a PE1 Router

To configure the Frame Relay DLCI-to-Ethernet VLAN 802.1Q feature on a PE1 router, use the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls label protocol ldp**
4. **interface** *type number*
5. **ip address** *ip-address mask*
6. **pseudowire-class** [*pw-class-name*]
7. **encapsulation mpls**
8. **interworking** {**ethernet** | **ip** | **vlan**}
9. **frame-relay switching**
10. **interface** *type slot/subslot/port*
11. **encapsulation frame-relay**
12. **frame-relay intf-type** [**dce**]
13. **connect** *connection-name interface dlci* {*interface dlci* | **l2transport**}
14. **xconnect** *ip-address vc-id* **pw-class** *pw-class-name*

15. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mpls label protocol ldp** **Example:** `Router(config)# mpls label protocol ldp`	Establishes the label distribution protocol for the platform.
Step 4	**interface** *type number* **Example:** `Router(config)# interface loopback 100`	Configures an interface type and enters interface configuration mode.
Step 5	**ip address** *ip-address mask* **Example:** `Router(config-if)# ip address 10.0.0.100 255.255.255.255`	Sets the primary or secondary IP address for an interface.
Step 6	**pseudowire-class** [*pw-class-name*] **Example:** `Router(config-if)# pseudowire-class atm-eth`	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
Step 7	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation.
Step 8	**interworking** {**ethernet** | **ip** | **vlan**} **Example:** `Router(config-pw)# interworking ip`	Specifies the type of pseudowire and the type of traffic that can flow across it.
Step 9	**frame-relay switching** **Example:** `Router(config-pw)# frame-relay switching`	Enables PVC switching on a Frame Relay DCE device.
Step 10	**interface** *type slot*/*subslot*/*port* **Example:** `Router(config-pw)# interface serial 2/0/0`	Configures an interface and enters interface configuration mode.

	Command or Action	Purpose
Step 11	**encapsulation frame-relay** **Example:** `Router(config-if)# encapsulation frame-relay`	Enables Frame Relay encapsulation.
Step 12	**frame-relay intf-type** [**dce**] **Example:** `Router(config-if)# frame-relay intf-type dce`	Configures a Frame Relay switch type.
Step 13	**connect** *connection-name interface dlci* {*interface dlci* | **l2transport**} **Example:** `Router(config-if)# connect one serial0 16 serial1 100`	Defines the connection between Frame Relay PVCs.
Step 14	**xconnect** *ip-address vc-id* **pw-class** *pw-class-name* **Example:** `Router(config-if)# xconnect 10.0.0.200 140 pw-class atm-eth`	Binds an AC to a pseudowire and configures an AToM static pseudowire.
Step 15	**end** **Example:** `Router(config-if-xconn)# end`	Exits xconnect configuration mode and returns to privileged EXEC mode.

Frame Relay DLCI-to-Ethernet VLAN 802.1Q on a PE2 Router

To configure the Frame Relay DLCI-to-Ethernet VLAN 802.1Q feature on a PE2 router, use the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls label protocol ldp**
4. **interface** *type number*
5. **ip address** *ip-address mask*
6. **pseudowire-class** [*pw-class-name*]
7. **encapsulation mpls**
8. **interworking** {**ethernet** | **ip** | **vlan**}
9. **interface** *type slot/subslot/port.subinterface-number*
10. **encapsulation dot1q** *vlan-id*
11. **xconnect** *ip-address vc-id* **pw-class** *pw-class-name*

12. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mpls label protocol ldp** **Example:** `Router(config)# mpls label protocol ldp`	Establishes the label distribution protocol for the platform.
Step 4	**interface** *type number* **Example:** `Router(config)# interface loopback 100`	Configures an interface type and enters interface configuration mode.
Step 5	**ip address** *ip-address mask* **Example:** `Router(config-if)# ip address 10.0.0.100 255.255.255.255`	Sets the primary or secondary IP address for an interface.
Step 6	**pseudowire-class** [*pw-class-name*] **Example:** `Router(config-if)# pseudowire-class atm-eth`	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
Step 7	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation.
Step 8	**interworking** {**ethernet** | **ip** | **vlan**} **Example:** `Router(config-pw)# interworking ip`	Specifies the type of pseudowire and the type of traffic that can flow across it.
Step 9	**interface** *type slot*/*subslot*/*port*.*subinterface-number* **Example:** `Router(config-pw)# interface gigabitethernet 5/1/0.3`	Configures an interface and enters interface configuration mode.

	Command or Action	Purpose
Step 10	**encapsulation dot1q** *vlan-id* **Example:** `Router(config-if)# encapsulation dot1q 1525`	Enables IEEE 802.1Q encapsulation of traffic on a specified subinterface in a VLAN.
Step 11	**xconnect** *ip-address vc-id* **pw-class** *pw-class-name* **Example:** `Router(config-if)# xconnect 10.0.0.100 140 pw-class atm-eth`	Binds an AC to a pseudowire and configures an AToM static pseudowire.
Step 12	**end** **Example:** `Router(config-if-xconn)# end`	Exits xconnect configuration mode and returns to privileged EXEC mode.

Note In the case of an Frame Relay DLCI-to-VLAN, the PE2 router configuration includes the **interworking** command for both bridged and routed interworking.

Note To verify the L2VPN interworking status and check the statistics, refer to the "Verifying L2VPN Interworking" section on page 35.

Verifying L2VPN Interworking

To verify the L2VPN status (in the AToM configuration), use the following commands:

- **show connection** [**all** | **name** | **id** | **elements** | **port**]
- **show xconnect** [**all** | **interface** | **peer**]
- **show mpls l2transport** [**binding** | **checkpoint** | **hw-capability** | **summary** | **vc**]
- **show mpls infrastructure lfd pseudowire vcid**

Configuration Examples for L2VPN Interworking

The following sections show examples of L2VPN interworking:

Frame Relay DLCI-to-Ethernet VLAN 802.1Q Using Bridged Internetworking: Example

The following example shows how to configure the Frame Relay DLCI-to-Ethernet VLAN 802.1Q feature using bridged interworking:

PE1 router	PE2 router
config t mpls label protocol ldp interface Loopback100 ip address 10.0.0.100 255.255.255.255 pseudowire-class fr-vlan encapsulation mpls interworking ethernet frame-relay switching interface serial 2/0/0:1 encapsulation frame-relay frame-relay intf-type dce connect mpls serial 2/0/0:1 567 l2transport xconnect 10.0.0.200 150 pw-class fr-vlan	config t mpls label protocol ldp interface Loopback200 ip address 10.0.0.200 255.255.255.255 pseudowire-class fr-vlan encapsulation mpls interworking ethernet interface gigabitethernet 5/1/0.3 encapsulation dot1q 1525 xconnect 10.0.0.100 150 pw-class fr-vlan

ATM AAL5-to-Ethernet VLAN 802.1Q Using Bridged Internetworking: Example

The following example shows how to configure the ATM AAL5-to-Ethernet VLAN 802.1Q feature using bridged interworking:

PE1 router	PE2 router
config t mpls label protocol ldp interface Loopback100 ip address 10.0.0.100 255.255.255.255 pseudowire-class atm-vlan encapsulation mpls interworking ethernet interface atm 2/0/0 pvc 0/200 l2transport encapsulation aal5snap xconnect 10.0.0.200 140 pw-class atm-vlan	config t mpls label protocol ldp interface Loopback200 ip address 10.0.0.200 255.255.255.255 pseudowire-class atm-vlan encapsulation mpls interworking ethernet interface gigabitethernet 5/1/0.3 encapsulation dot1q 1525 xconnect 10.0.0.100 140 pw-class atm-vlan

ATM AAL5-to-Ethernet Port Using Routed Interworking: Example

The following example shows how to configure the ATM AAL5-to-Ethernet Port feature using routed interworking:

PE1 router	PE2 router
config t mpls label protocol ldp interface Loopback100 ip address 10.0.0.100 255.255.255.255 pseudowire-class atm-eth encapsulation mpls interworking ip interface atm 2/0.1 pvc 0/200 l2transport encapsulation aal5 xconnect 10.0.0.200 140 pw-class atm-eth	config t mpls label protocol ldp interface Loopback200 ip address 10.0.0.200 255.255.255.255 pseudowire-class atm-eth encapsulation mpls interworking ip interface gigabitethernet 5/1/0 xconnect 10.0.0.100 140 pw-class atm-eth

Frame Relay DLCI-to-Ethernet Port Using Routed Interworking: Example

The following example shows how to configure the Frame Relay DLCI-to-Ethernet Port feature using routed interworking:

PE1 router	PE2 router
config t mpls label protocol ldp interface Loopback100 ip address 10.0.0.100 255.255.255.255 pseudowire-class fr-eth encapsulation mpls interworking ip frame-relay switching interface serial 2/0/0:1 encapsulation frame-relay frame-relay intf-type dce frame-relay interface-dlci 567 switched connect fr-vlan-1 POS2/3/1 151 l2transport xconnect 10.0.0.200 151 pw-class pw-class-bridge	config t mpls label protocol ldp interface Loopback200 ip address 10.0.0.200 255.255.255.255 pseudowire-class fr-eth encapsulation mpls interworking ip interface gigabitethernet 5/1/0 xconnect 10.0.0.100 150 pw-class fr-eth

Ethernet-to-VLAN over AToM—Bridged: Example

The following example shows how to configure Ethernet-to-VLAN over AToM in a PE router:

PE1 router	PE2 router
ip cef ! mpls label protocol ldp mpls ldp router-id Loopback0 force ! pseudowire-class atom encapsulation mpls ! interface Loopback0 ip address 10.9.9.9 255.255.255.255 ! interface FastEthernet0/0 no ip address ! interface FastEthernet1/0 xconnect 10.8.8.8 123 pw-class atom	ip cef ! mpls label protocol ldp mpls ldp router-id Loopback0 force ! pseudowire-class atom-eth-iw encapsulation mpls interworking ethernet ! interface Loopback0 ip address 10.8.8.8 255.255.255.255 ! interface FastEthernet1/0.1 encapsulation dot1q 100 xconnect 10.9.9.9 123 pw-class atom-eth-iw

VLAN-to-ATM AAL5 over AToM (Bridged): Example

The following example shows the configuration of VLAN-to-ATM AAL5 over AToM:

PE1 router	PE2 router
ip cef ! mpls ip mpls label protocol ldp mpls ldp router-id Loopback0 ! pseudowire-class inter-ether encapsulation mpls interworking ethernet ! interface Loopback0 ip address 10.8.8.8 255.255.255.255 ! interface ATM1/0.1 point-to-point pvc 0/100 l2transport encapsulation aal5snap xconnect 10.9.9.9 123 pw-class inter-ether ! interface FastEthernet1/0 xconnect 10.9.9.9 1 pw-class inter-ether ! router ospf 10 log-adjacency-changes network 10.8.8.8 0.0.0.0 area 0 network 10.1.1.1 0.0.0.0 area 0	ip cef ! mpls ip mpls label protocol ldp mpls ldp router-id Loopback0 ! pseudowire-class inter-ether encapsulation mpls interworking ethernet ! interface Loopback0 ip address 10.9.9.9 255.255.255.255 ! interface FastEthernet0/0 no ip address ! interface FastEthernet0/0.1 encapsulation dot1Q 10 xconnect 10.8.8.8 123 pw-class inter-ether ! router ospf 10 log-adjacency-changes network 10.9.9.9 0.0.0.0 area 0 network 10.1.1.2 0.0.0.0 area 0

Ethernet/VLAN-to-PPP over AToM (Routed): Example

The following example shows the configuration of Ethernet VLAN-to-PPP over AToM

PE1 router	PE2 router
configure terminal mpls label protocol ldp mpls ldp router-id Loopback0 mpls ip ! pseudowire-class ppp-ether encapsulation mpls interworking ip ! interface Loopback0 ip address 10.8.8.8 255.255.255.255 no shutdown ! interface POS2/0/1 no ip address encapsulation ppp no peer default ip address ppp ipcp address proxy 10.10.10.1 xconnect 10.9.9.9 300 pw-class ppp-ether no shutdown	configure terminal mpls label protocol ldp mpls ldp router-id Loopback0 mpls ip ! pseudowire-class ppp-ether encapsulation mpls interworking ip ! interface Loopback0 ip address 10.9.9.9 255.255.255.255 no shutdown ! interface GigabitEthernet6/2 xconnect 10.8.8.8 300 pw-class ppp-ether no shutdown

ATM VC-to-VC Local Switching (Different Port): Example

The following example shows the configuration of ATM VC-to-VC local switching:

CE1 router	CE2 router	PE router

interface ATM1/0
 no ip address
 atm clock INTERNAL
 no atm ilmi-keepalive
 no atm enable-ilmi-trap
 	
interface ATM1/0
 ip address 10.1.1.1 255.255.255.0
 no atm enable-ilmi-trap
 pvc 0/100
  encapsulation aal5snap
	interface ATM3/0
	 no ip address
	 atm clock INTERNAL
	 no atm ilmi-keepalive
	 no atm enable-ilmi-trap
	!
	interface ATM3/0.1 multipoint
	 ip address 10.1.1.2 255.255.255.0
	 no atm enable-ilmi-trap
	 pvc 0/50
	  protocol ip 10.1.1.1
	  encapsulation aal5snap
		interface ATM0/1/0
		 no ip address
		 atm clock INTERNAL
		 no atm enable-ilmi-trap
		!
		interface ATM0/1/0.50 point-to-point
		 no atm enable-ilmi-trap
		 pvc 0/50 l2transport
		  encapsulation aal5
		 !
		!
		interface ATM0/1/1
		 no ip address
		 atm clock INTERNAL
		 no atm enable-ilmi-trap
		!
		interface ATM0/1/1.100 point-to-point
		 no atm enable-ilmi-trap
		 pvc 0/100 l2transport
		  encapsulation aal5
		
		connect con_atm ATM0/1/1 0/100 ATM0/1/0 0/50

ATM VP-to-VP Local Switching (Different Port): Example

The following example shows the configuration of ATM VP-to-VP local switching:

CE1 router	CE2 router	PE router

interface ATM1/0
 no ip address
 atm clock INTERNAL
 no atm enable-ilmi-trap
!
interface ATM1/0.1 point-to-point
 ip address 10.1.1.1 255.255.255.0
 no atm enable-ilmi-trap
 pvc 100/100
  encapsulation aal5snap
	interface ATM3/0
	 no ip address
	 atm clock INTERNAL
	 no atm ilmi-keepalive
	 no atm enable-ilmi-trap
	!
	interface ATM3/0.1 point-to-point
	 ip address 10.1.1.2 255.255.255.0
	 no atm enable-ilmi-trap
	 pvc 100/100
	  encapsulation aal5snap
		interface ATM0/1/0
		 no ip address
		 atm clock INTERNAL
		 no atm ilmi-keepalive
		 no atm enable-ilmi-trap
		!
		interface ATM0/1/0.50 multipoint
		 atm pvp 100 l2transport
		 no atm enable-ilmi-trap
		!
		interface ATM0/1/1
		 no ip address
		 atm clock INTERNAL
		 no atm ilmi-keepalive
		 no atm enable-ilmi-trap
		!
		interface ATM0/1/1.100 multipoint
		 atm pvp 100 l2transport
		 no atm enable-ilmi-trap
		
		connect atm_con ATM0/1/1 100 ATM0/1/0 100

Additional References

The following sections provide references related to the L2VPN Interworking feature.

Related Documents

Related Topic	Document Title
Cisco IOS commands	*Cisco IOS Master Commands List, All Releases*
MPLS commands	*Multiprotocol Label Switching Command Reference*
Any Transport over MPLS	*Any Transport over MPLS*

Standards

Standards	Title
draft-ietf-l2tpext-l2tp-base-03.txt	*Layer Two Tunneling Protocol (Version 3) 'L2TPv3'*
draft-martini-l2circuit-trans-mpls-09.txt	*Transport of Layer 2 Frames Over MPLS*
draft-ietf-pwe3-frame-relay-03.txt.	*Encapsulation Methods for Transport of Frame Relay over MPLS Networks*
draft-martini-l2circuit-encap-mpls-04.txt.	*Encapsulation Methods for Transport of Layer 2 Frames Over IP and MPLS Networks*
draft-ietf-pwe3-ethernet-encap-08.txt.	*Encapsulation Methods for Transport of Ethernet over MPLS Networks*
draft-ietf-pwe3-hdlc-ppp-encap-mpls-03.txt.	*Encapsulation Methods for Transport of PPP/HDLC over MPLS Networks*
draft-ietf-ppvpn-l2vpn-00.txt.	*An Architecture for L2VPNs*

MIBs

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS XE software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

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

Feature Information for L2VPN Interworking

Table 3 lists the features in this module and provides links to specific configuration information.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS XE software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 3 lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 3 Feature Information for L2VPN Interworking

Feature Name	Releases	Feature Information
L2VPN Interworking	Cisco IOS XE Release 2.4 Cisco IOS XE Release 3.3S	This feature allows disparate ACs to be connected. An interworking function facilitates the translation between the different Layer 2 encapsulations. The following sections provides information about this feature: • Restrictions for L2VPN Interworking, page 2 • Information About L2VPN Interworking, page 5 • How to Configure L2VPN Interworking, page 17 The following commands were introduced or modified: **debug frame-relay pseudowire**, **debug ssm**, **interworking**, **mtu**, **pseudowire-class**, **show l2tun session**, **show l2tun tunnel**, **show mpls l2transport vc**, **show platform**.
L2VPN Interworking: Ethernet VLAN to Frame Relay	Cisco IOS XE Release 3.3S	This feature allows interworking of Ethernet VLANs with Frame Relay DLCIs. The following command was modified: **interworking** The following section provides information about this feature: • Ethernet/VLAN-to-Frame Relay Interworking, page 11
L2VPN Interworking–Ethernet VLAN to PPP	Cisco IOS XE Release 3.3S	The L2VPN interworking – Ethernet VLAN-to-PPP feature allows disparate ACs to be connected. An interworking function facilitates the translation between the following Layer 2 encapsulations. • Ethernet/VLAN-to-PPP Interworking The following sections provide information about this feature: • PPP Interworking Restrictions, page 3 • Static IP Addresses for L2VPN Interworking for PPP, page 17 • How to Configure L2VPN Interworking, page 17 • Ethernet/VLAN-to-PPP over AToM (Routed): Example, page 39