



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.

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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 Table at the end of this document.

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

Prerequisites for L2VPN Interworking

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



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Restrictions for L2VPN Interworking

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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.

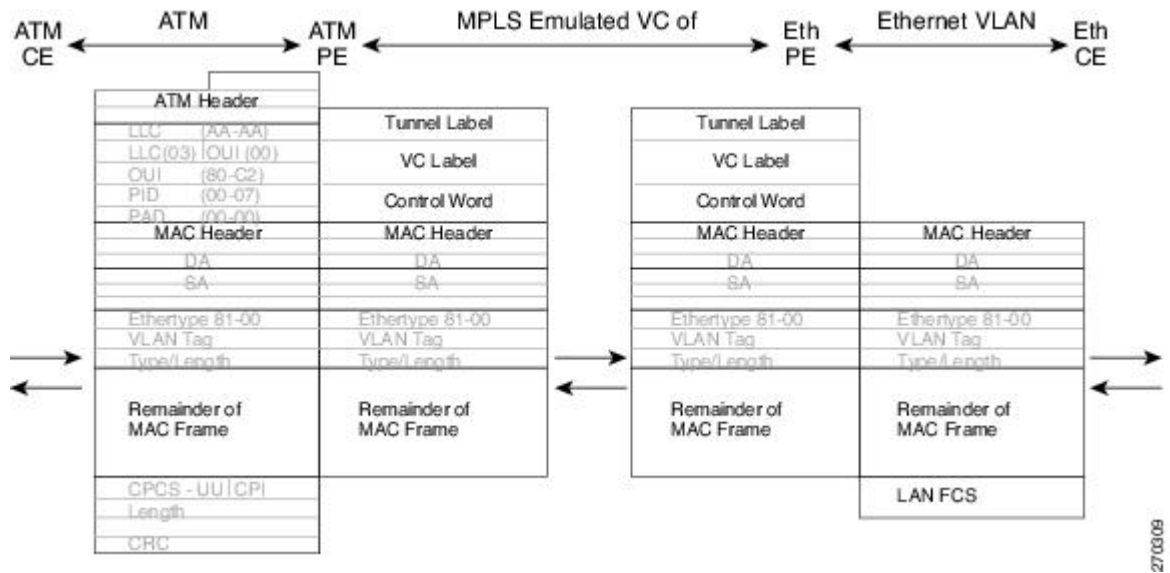
Ethernet VLAN-to-ATM AAL5 Interworking Restrictions

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 (see the figure below).

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



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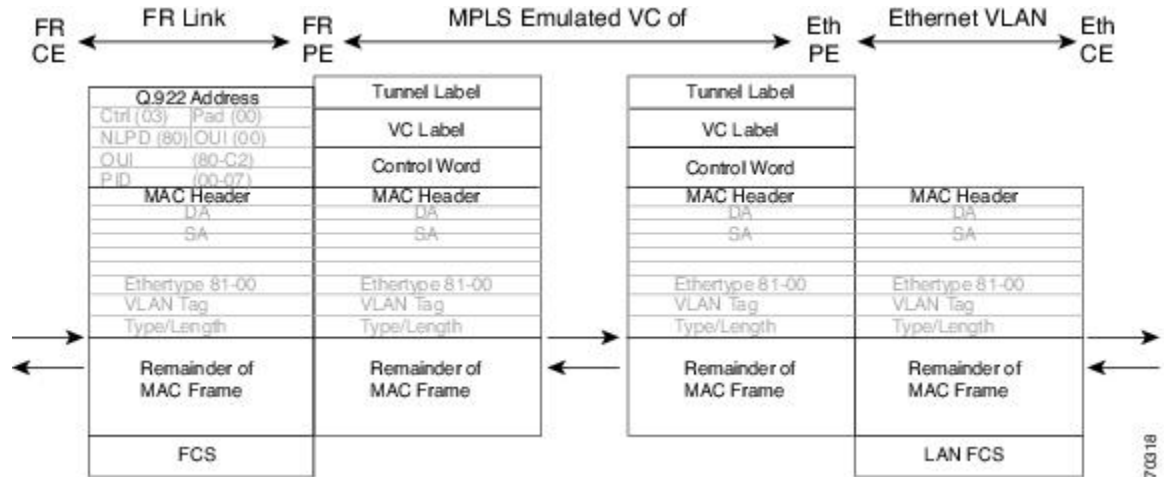
Ethernet VLAN-to-Frame Relay Interworking Restrictions

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 (see the figure below).

- 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



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Information About L2VPN Interworking

- [Overview of L2VPN Interworking, page 5](#)
- [L2VPN Interworking Modes, page 5](#)
- [Ethernet VLAN-to-ATM AAL5 Interworking, page 7](#)
- [Ethernet VLAN-to-Frame Relay Interworking, page 10](#)
- [ATM Local Switching, page 13](#)
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- [Static IP Addresses for L2VPN Interworking for PPP, page 15](#)

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, page 6](#)
- [IP or Routed Interworking, page 6](#)

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. The table below 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:

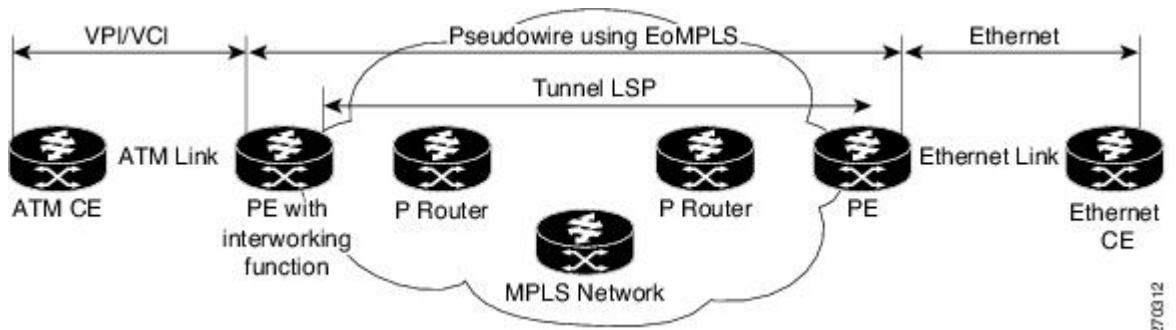
- [ATM AAL5-to-Ethernet Port AToM--Bridged Interworking, page 7](#)
- [ATM AAL5-to-Ethernet VLAN 802.1Q AToM--Bridged Interworking, page 9](#)
- [ATM-to-Ethernet--Routed Interworking, page 9](#)

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 (see the figure below).

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



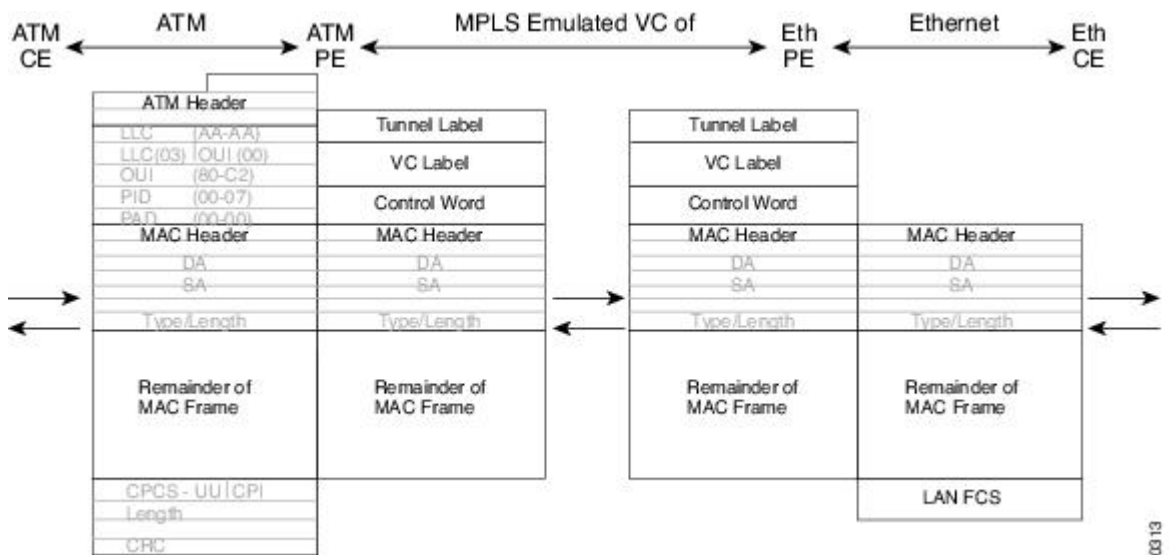
The advantage of this architecture is that the Ethernet PE router (connected to the Ethernet segment) operates similarly to Ethernet like-to-like services.

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) (see the figure below).

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

The figure below 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

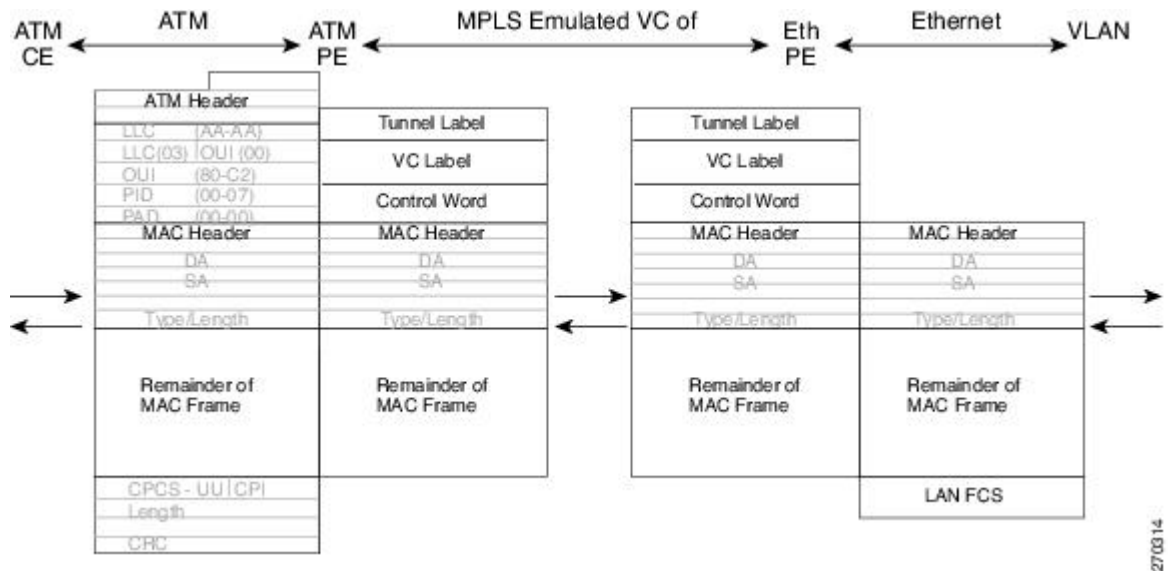
This interworking type provides interoperability between the ATM attachment VC and Ethernet VLAN attachment VC connected to different PE routers. Bridged encapsulation corresponding to the bridged (Ethernet) interworking mechanism is used.

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 the figure below).

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 the figure below.

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. The figure below 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.

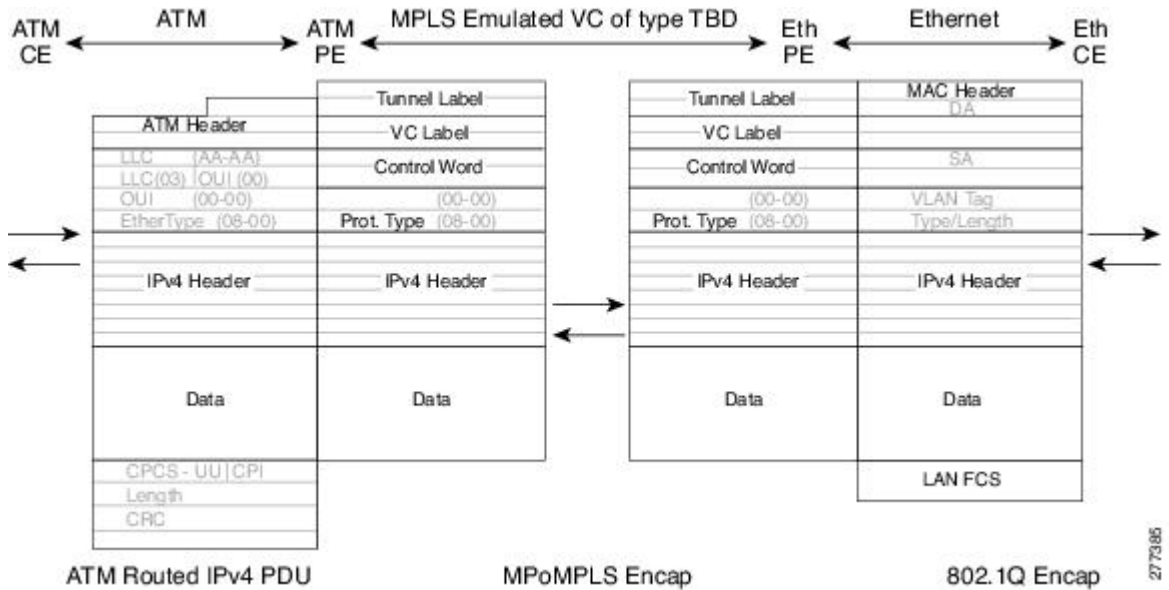
The address resolution is done at the ATM PE router; it is required when the ATM CE router does an inverse ARP. It is not required when the ATM CE router is configured using Point-to-Point (P2P) subinterfaces or static maps.

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:

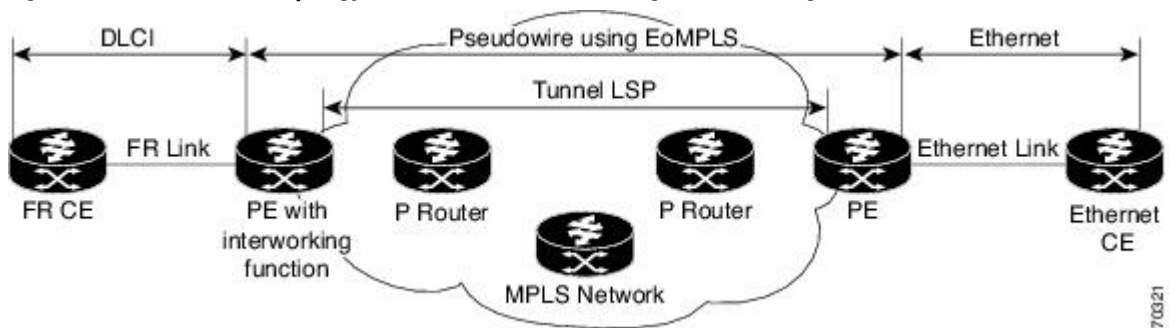
- [Frame Relay DLCI-to-Ethernet Port AToM--Bridged Interworking, page 10](#)
- [Frame Relay DLCI-to-Ethernet VLAN 802.1Q AToM--Bridged Interworking, page 11](#)
- [Frame Relay DLCI-to-Ethernet VLAN QotIQ QinQ AToM - Bridged Interworking, page 12](#)

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 (see the figure below). 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) (see the figure below).

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)

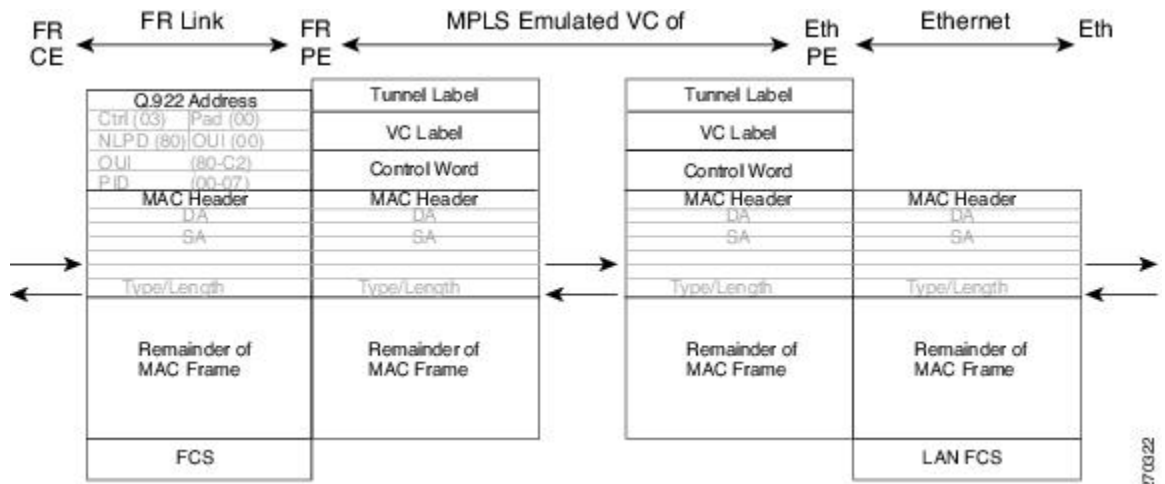
The PE router automatically supports translation of both Cisco and IETF Frame Relay encapsulation types coming from the CE, but translates only to IETF when sending to the CE router. This is not a problem for the Cisco CE router, because it can handle IETF encapsulation on receipt even if it is configured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

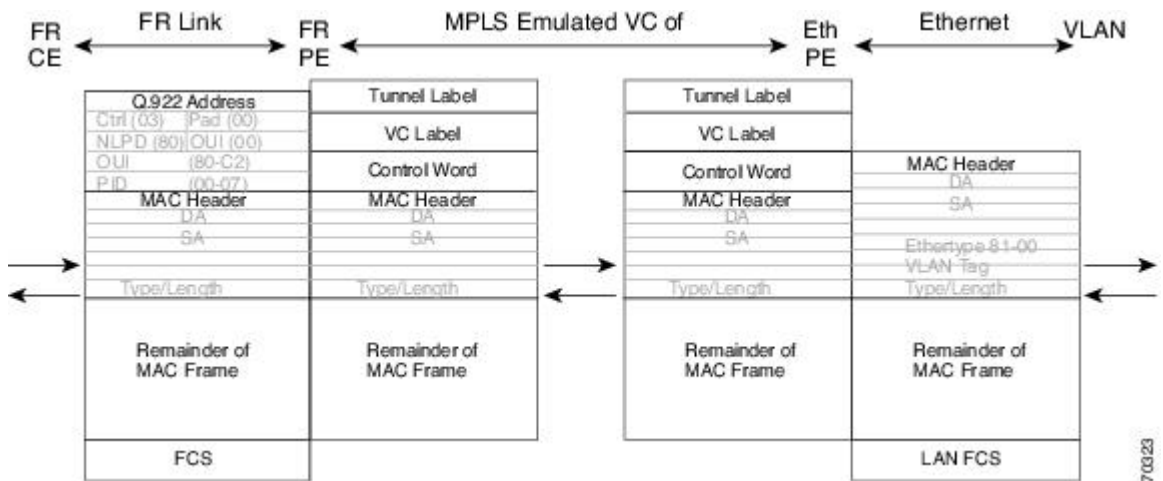
This interworking type provides interoperability between the Frame Relay attachment VC and Ethernet VLAN Attachment VC connected to different PE routers. The bridged encapsulation corresponding to the bridged (Ethernet) interworking mechanism is used.

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 the figure above).

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 below shows the protocol stack for FR-to-VLAN AToM bridged interworking.

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



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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. The table below lists the supported ATM local switching combinations.

Table 2 *ATM local switching - supported combinations*

Port Mode	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 13](#)
- [VP-to-VP Local Switching, page 14](#)

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

- [Configuring L2VPN Interworking, page 16](#)
- [Configuring Ethernet VLAN-to-ATM AAL5 Interworking, page 17](#)
- [Configuring Ethernet VLAN-to-Frame Relay Interworking, page 27](#)
- [Verifying L2VPN Interworking, page 38](#)

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. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	pseudowire-class <i>name</i> Example: Router(config)# pseudowire-class class1	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.

Command or Action	Purpose
Step 4 <code>encapsulation { mpls l2tpv3 }</code> Example: <code>Router(config-pw)# encapsulation mpls</code>	Specifies the tunneling encapsulation, which is either mpls or l2tpv3 .
Step 5 <code>interworking { ethernet ip vlan }</code> Example: <code>Router(config-pw)# interworking ip</code>	Specifies the type of pseudowire and the type of traffic that can flow across it.
Step 6 <code>end</code> Example: <code>Router(config-pw)# end</code>	Exits pseudowire class configuration mode and returns to privileged EXEC mode.

- [Verifying the L2VPN Configuration, page 17](#)

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 18](#)
- [ATM AAL5-to-Ethernet Port on a PE2 Router, page 20](#)
- [ATM AAL5-to-Ethernet VLAN 802.1Q on a PE1 Router, page 22](#)
- [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* **transport**
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. <ul style="list-style-type: none"> • 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.

	Command or Action	Purpose
Step 4	<p>interface <i>type number</i></p> <p>Example:</p> <pre>Router(config)# interface loopback 100</pre>	Configure an interface type and enters interface configuration mode.
Step 5	<p>ip address <i>ip-address mask</i></p> <p>Example:</p> <pre>Router(config-if)# ip address 10.0.0.100 255.255.255.255</pre>	Sets the primary or secondary IP address for an interface.
Step 6	<p>pseudowire-class [<i>pw-class-name</i>]</p> <p>Example:</p> <pre>Router(config-if)# pseudowire-class atm-eth</pre>	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
Step 7	<p>encapsulation <i>mpls</i></p> <p>Example:</p> <pre>Router(config-pw)# encapsulation mpls</pre>	Specifies the tunneling encapsulation.
Step 8	<p>interworking {<i>ethernet ip vlan</i>}</p> <p>Example:</p> <pre>Router(config-pw)# interworking ip</pre>	Specifies the type of pseudowire and the type of traffic that can flow across it.
Step 9	<p>interface atm <i>slot / subslot / port . subinterface number</i></p> <p>Example:</p> <pre>Router(config-pw)# interface atm 2/0/0.1</pre>	Configures an ATM interface and enters interface configuration mode.
Step 10	<p>pvc [<i>name</i>] <i>vpi / vci</i> l2transport</p> <p>Example:</p> <pre>Router(config-subif)# pvc 0/200 l2transport</pre>	Assigns a name to an ATM permanent virtual circuit (PVC) and enters ATM virtual circuit configuration mode.

Command or Action	Purpose
Step 11 <code>encapsulation aal5snap</code> Example: <pre>Router(config-if-atm-member)# encapsulation aal5snap</pre>	Configures the ATM AAL and encapsulation type for an ATM VC.
Step 12 <code>xconnect ip-address vc-id pw-class pw-class-name</code> Example: <pre>Router(config-if-atm-member)# xconnect 10.0.0.200 140 pw-class atm-eth</pre>	Binds an AC to a pseudowire and configures an ATOM static pseudowire.
Step 13 <code>end</code> Example: <pre>Router(config-if-xconn)# end</pre>	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	<p>enable</p> <p>Example:</p> <pre>Router> enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> Enter your password if prompted.
Step 2	<p>configure terminal</p> <p>Example:</p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
Step 3	<p>mpls label protocol ldp</p> <p>Example:</p> <pre>Router(config)# mpls label protocol ldp</pre>	<p>Establishes the label distribution protocol for the platform.</p>
Step 4	<p>interface <i>type number</i></p> <p>Example:</p> <pre>Router(config)# interface loopback 100</pre>	<p>Configure an interface type and enters interface configuration mode.</p>
Step 5	<p>ip address <i>ip-address mask</i></p> <p>Example:</p> <pre>Router(config-if)# ip address 10.0.0.100 255.255.255.255</pre>	<p>Sets the primary or secondary IP address for an interface.</p>
Step 6	<p>pseudowire-class [<i>pw-class-name</i>]</p> <p>Example:</p> <pre>Router(config-if)# pseudowire-class atm-eth</pre>	<p>Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.</p>
Step 7	<p>encapsulation mpls</p> <p>Example:</p> <pre>Router(config-pw)# encapsulation mpls</pre>	<p>Specifies the tunneling encapsulation.</p>

	Command or Action	Purpose
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.
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	<p>enable</p> <p>Example:</p> <pre>Router> enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	<p>configure terminal</p> <p>Example:</p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
Step 3	<p>mpls label protocol ldp</p> <p>Example:</p> <pre>Router(config)# mpls label protocol ldp</pre>	<p>Establishes the label distribution protocol for the platform.</p>
Step 4	<p>interface <i>type number</i></p> <p>Example:</p> <pre>Router(config)# interface loopback 100</pre>	<p>Configure an interface type and enters interface configuration mode.</p>

	Command or Action	Purpose
Step 5	<p><code>ip address ip-address mask</code></p> <p>Example:</p> <pre>Router(config-if)# ip address 10.0.0.100 255.255.255.255</pre>	Sets the primary or secondary IP address for an interface.
Step 6	<p><code>pseudowire-class [pw-class-name]</code></p> <p>Example:</p> <pre>Router(config-if)# pseudowire-class atm-eth</pre>	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
Step 7	<p><code>encapsulation mpls</code></p> <p>Example:</p> <pre>Router(config-pw)# encapsulation mpls</pre>	Specifies the tunneling encapsulation.
Step 8	<p><code>interworking { ethernet ip vlan }</code></p> <p>Example:</p> <pre>Router(config-pw)# interworking ip</pre>	Specifies the type of pseudowire and the type of traffic that can flow across it.
Step 9	<p><code>interface atm slot / subslot / port . subinterface number</code></p> <p>Example:</p> <pre>Router(config-pw)# interface atm 2/0/0.1</pre>	Configure an ATM interface and enters interface configuration mode.
Step 10	<p><code>pvc [name] vpi / vci l2transport</code></p> <p>Example:</p> <pre>Router(config-subif)# pvc 0/200 l2transport</pre>	Assigns a name to an ATM permanent virtual circuit (PVC) and enters ATM virtual circuit configuration mode.
Step 11	<p><code>encapsulation aal5snap</code></p> <p>Example:</p> <pre>Router(config-if-atm-member)# encapsulation aal5snap</pre>	Configures the ATM AAL and encapsulation type for an ATM VC.

Command or Action	Purpose
<p>Step 12 <code>xconnect ip-address vc-id pw-class pw-class-name</code></p> <p>Example:</p> <pre>Router(config-if-atm-member)# xconnect 10.0.0.200 140 pw-class atm-eth</pre>	<p>Binds an AC to a pseudowire and configures an AToM static pseudowire.</p>
<p>Step 13 <code>end</code></p> <p>Example:</p> <pre>Router(config-if-xconn)# end</pre>	<p>Exits xconnect configuration mode and returns to privileged EXEC mode.</p>

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
<p>Step 1 <code>enable</code></p> <p>Example:</p> <pre>Router> enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> • Enter your password if prompted.

	Command or Action	Purpose
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.

	Command or Action	Purpose
Step 9	interface <i>type slot / subslot / port . subinterface-number</i> Example: Router(config-pw)# interface gigabitethernet 5/1/0.3	Configures an interface and enters interface configuration mode.
Step 10	encapsulation dot1q <i>vlan-id</i> 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 <i>ip-address vc-id pw-class pw-class-name</i> 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](#), page 38.

Configuring Ethernet VLAN-to-Frame Relay Interworking

This section explains the following AToM configurations and provides examples. The Network Topology for FR-to-Ethernet AToM Bridged Interworking figure above illustrates different AToM configurations.

- [Frame Relay DLCI-to-Ethernet Port on a PE1 Router](#), page 28
- [Frame Relay DLCI-to-Ethernet Port on a PE2 router](#), page 30
- [Frame Relay DLCI-to-Ethernet VLAN 802.1Q on a PE1 Router](#), page 32
- [Frame Relay DLCI-to-Ethernet VLAN 802.1Q on a PE2 Router](#), page 35

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. <ul style="list-style-type: none"> • 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.

	Command or Action	Purpose
Step 4	interface <i>type number</i> Example: Router(config)# interface loopback 100	Configures an interface type and enters interface configuration mode.
Step 5	ip address <i>ip-address mask</i> 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 [<i>pw-class-name</i>] 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.
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 <i>type slot / subslot / port</i> 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.

Command or Action	Purpose
<p>Step 11 <code>connect connection-name interface dlci {interface dlci l2transport}</code></p> <p>Example:</p> <pre>Router(config-if)# connect fr-vlan-1 POS2/3/1 151 l2transport</pre>	<p>Defines the connection between Frame Relay PVCs.</p>
<p>Step 12 <code>xconnect ip-address vc-id pw-class pw-class-name</code></p> <p>Example:</p> <pre>Router(config-if)# xconnect 10.0.0.200 151 pw-class pw- class-bridge</pre>	<p>Binds an AC to a pseudowire and configures an AToM static pseudowire.</p>
<p>Step 13 <code>end</code></p> <p>Example:</p> <pre>Router(config-if-xconn)# end</pre>	<p>Exits xconnect configuration mode and returns to privileged EXEC mode.</p>

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	<p>enable</p> <p>Example:</p> <pre>Router> enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> Enter your password if prompted.
Step 2	<p>configure terminal</p> <p>Example:</p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
Step 3	<p>mpls label protocol ldp</p> <p>Example:</p> <pre>Router(config)# mpls label protocol ldp</pre>	<p>Establishes the label distribution protocol for the platform.</p>
Step 4	<p>interface <i>type number</i></p> <p>Example:</p> <pre>Router(config)# interface loopback 100</pre>	<p>Configures an interface type and enters interface configuration mode.</p>
Step 5	<p>ip address <i>ip-address mask</i></p> <p>Example:</p> <pre>Router(config-if)# ip address 10.0.0.100 255.255.255.255</pre>	<p>Sets the primary or secondary IP address for an interface.</p>
Step 6	<p>pseudowire-class [<i>pw-class-name</i>]</p> <p>Example:</p> <pre>Router(config-if)# pseudowire-class atm-eth</pre>	<p>Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.</p>
Step 7	<p>encapsulation mpls</p> <p>Example:</p> <pre>Router(config-pw)# encapsulation mpls</pre>	<p>Specifies the tunneling encapsulation.</p>

	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 gigabitethernet 2/0/0	Configures an interface and enters interface configuration mode.
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 dlc* {*interface dlc* | **I2transport**}
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. <ul style="list-style-type: none"> • 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 <i>type number</i> Example: Router(config)# interface loopback 100	Configures an interface type and enters interface configuration mode.

Command or Action	Purpose
<p>Step 5 <code>ip address ip-address mask</code></p> <p>Example:</p> <pre>Router(config-if)# ip address 10.0.0.100 255.255.255.255</pre>	Sets the primary or secondary IP address for an interface.
<p>Step 6 <code>pseudowire-class [pw-class-name]</code></p> <p>Example:</p> <pre>Router(config-if)# pseudowire-class atm-eth</pre>	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
<p>Step 7 <code>encapsulation mpls</code></p> <p>Example:</p> <pre>Router(config-pw)# encapsulation mpls</pre>	Specifies the tunneling encapsulation.
<p>Step 8 <code>interworking { ethernet ip vlan }</code></p> <p>Example:</p> <pre>Router(config-pw)# interworking ip</pre>	Specifies the type of pseudowire and the type of traffic that can flow across it.
<p>Step 9 <code>frame-relay switching</code></p> <p>Example:</p> <pre>Router(config-pw)# frame-relay switching</pre>	Enables PVC switching on a Frame Relay DCE device.
<p>Step 10 <code>interface type slot / subslot / port</code></p> <p>Example:</p> <pre>Router(config-pw)# interface serial 2/0/0</pre>	Configures an interface and enters interface configuration mode.
<p>Step 11 <code>encapsulation frame-relay</code></p> <p>Example:</p> <pre>Router(config-if)# encapsulation frame-relay</pre>	Enables Frame Relay encapsulation.

Command or Action	Purpose
<p>Step 12 <code>frame-relay intf-type [dce]</code></p> <p>Example:</p> <pre>Router(config-if)# frame-relay intf-type dce</pre>	Configures a Frame Relay switch type.
<p>Step 13 <code>connect connection-name interface dlcI {interface dlcI I2transport}</code></p> <p>Example:</p> <pre>Router(config-if)# connect one serial0 16 serial1 100</pre>	Defines the connection between Frame Relay PVCs.
<p>Step 14 <code>xconnect ip-address vc-id pw-class pw-class-name</code></p> <p>Example:</p> <pre>Router(config-if)# xconnect 10.0.0.200 140 pw-class atm-eth</pre>	Binds an AC to a pseudowire and configures an AToM static pseudowire.
<p>Step 15 <code>end</code></p> <p>Example:</p> <pre>Router(config-if-xconn)# end</pre>	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. <ul style="list-style-type: none"> • 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 <i>type number</i> Example: Router(config)# interface loopback 100	Configures an interface type and enters interface configuration mode.

	Command or Action	Purpose
Step 5	<p>ip address <i>ip-address mask</i></p> <p>Example:</p> <pre>Router(config-if)# ip address 10.0.0.100 255.255.255.255</pre>	Sets the primary or secondary IP address for an interface.
Step 6	<p>pseudowire-class [<i>pw-class-name</i>]</p> <p>Example:</p> <pre>Router(config-if)# pseudowire-class atm-eth</pre>	Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.
Step 7	<p>encapsulation mpls</p> <p>Example:</p> <pre>Router(config-pw)# encapsulation mpls</pre>	Specifies the tunneling encapsulation.
Step 8	<p>interworking {ethernet ip vlan}</p> <p>Example:</p> <pre>Router(config-pw)# interworking ip</pre>	Specifies the type of pseudowire and the type of traffic that can flow across it.
Step 9	<p>interface <i>type slot / subslot / port . subinterface-number</i></p> <p>Example:</p> <pre>Router(config-pw)# interface gigabitethernet 5/1/0.3</pre>	Configures an interface and enters interface configuration mode.
Step 10	<p>encapsulation dot1q <i>vlan-id</i></p> <p>Example:</p> <pre>Router(config-if)# encapsulation dot1q 1525</pre>	Enables IEEE 802.1Q encapsulation of traffic on a specified subinterface in a VLAN.
Step 11	<p>xconnect <i>ip-address vc-id pw-class pw-class-name</i></p> <p>Example:</p> <pre>Router(config-if)# xconnect 10.0.0.100 140 pw-class atm-eth</pre>	Binds an AC to a pseudowire and configures an AToM static pseudowire.

Command or Action	Purpose
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, page 38](#).

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

- [Frame Relay DLCI-to-Ethernet VLAN 802.1Q Using Bridged Internetworking Example, page 38](#)
- [ATM AAL5-to-Ethernet VLAN 802.1Q Using Bridged Internetworking Example, page 39](#)
- [ATM AAL5-to-Ethernet Port Using Routed Interworking Example, page 39](#)
- [Frame Relay DLCI-to-Ethernet Port Using Routed Interworking Example, page 40](#)
- [Ethernet-to-VLAN over AToM--Bridged Example, page 40](#)
- [VLAN-to-ATM AAL5 over AToM \(Bridged\) Example, page 41](#)
- [Ethernet VLAN-to-PPP over AToM \(Routed\) Example, page 42](#)
- [ATM VC-to-VC Local Switching \(Different Port\) Example, page 43](#)
- [ATM VP-to-VP Local Switching \(Different Port\) Example, page 44](#)

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
<pre> 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 </pre>	<pre> 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 </pre>

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
<pre> 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 </pre>	<pre> 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 </pre>

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
<pre> 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 </pre>	<pre> 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 </pre>

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

```

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

```

PE2 router

```

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
<pre> 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 </pre>	<pre> 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 </pre>

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

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
<pre>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</pre>	<pre>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</pre>	<pre>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</pre>

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
<pre>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</pre>	<pre>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</pre>	<pre>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</pre>

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	<i>Multiprotocol Label Switching Command Reference</i>
Any Transport over MPLS	Any Transport over MPLS

Standards

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

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

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

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

Table 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 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

Feature Name	Releases	Feature Information
L2VPN Interworking-Ethernet VLAN to PPP	Cisco IOS XE Release 3.3S	<p>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.</p> <ul style="list-style-type: none">Ethernet/VLAN-to-PPP Interworking

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